



FUEL SYSTEMS

Learning objectives

⇒ Terminal Learning Objective

- Overhaul the engine so that it runs efficiently with a ± 5 percent to the criteria listed in the references.

ENABLING LEARNING OBJECTIVES

- ⇒ Diagnose the fuel system
- ⇒ Adjust fuel injectors
- ⇒ Adjust the governor

ELO's Continued

- ⇒ Adjust the fuel injection pump
- ⇒ Perform a secondary fuel filter pressure test
- ⇒ Perform misfiring cylinder test

ELO's Continued

- ⇒ Inspect the injection pump
- ⇒ Disassemble the injection pump
- ⇒ Inspect the internal components of the injection pump

ELO's Continued

- ➡ Assemble the injection pump
- ➡ Adjust the governor on the injection pump

Components common to all Fuel Systems

➡ Fuel tank

Reservoir for fuel

Contains baffle plates that strengthen the sides

Aids in the cooling of fuel

In general, the fuel tank is constructed to store enough fuel so the equipment can operate at 80% of its workload for 8 hours without being refueled

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Check valves

- ⇒ Installed in fuel line between fuel tank and primary fuel filter
- ⇒ The main purpose of the check valve is to prevent fuel from returning to the fuel tank when the engine is shut down

Primary Fuel Filter

- ⇒ Located between the check valve and the fuel pump
- ⇒ Functions under suction
- ⇒ Strains large particle of dirt and debris from fuel
- ⇒ Has one inlet and two outlets
- ⇒ One outlet is usually plugged depending on the placement and design of the engine

Fuel Pumps

- ➔ All systems incorporate a small positive displacement pump
- ➔ TRAM uses a single acting positive displacement pump
- ➔ LRT 110/EBFL use single acting positive displacement diaphragm pump
- ➔ The Caterpillar 3306 uses a positive displacement piston type pump

Secondary Fuel Filter

- ⇒ Located between the fuel pump and the fuel injection pump
- ⇒ Functions under pressure
- ⇒ Strains smaller particles of dirt and debris that may harm the injection pump

Fuel Injection Pumps/Systems

- ➔ Fuel injection systems have six basic functions
 1. Store, clean, and transfer fuel
 2. To meter the quantity of fuel required at all loads and speeds
 3. To start injection at the right time
 4. To ensure quick beginning and ending of injection
 5. To inject the fuel at rate necessary to control combustion and pressure in the cylinder
 6. Direct, distribute, and atomize the fuel uniformly

Two Basic types of Fuel injection systems

- ⇒ Group 1
 - ⇒ A gear- or cam-driven high-pressure pump that supplies highly pressurized fuel by way of high-pressure fuel lines to the injector nozzles.
- ⇒ Types of Group 1 injection systems
 - ⇒ American Bosch
 - ⇒ CAV
 - ⇒ Caterpillar
 - ⇒ Robert Bosch
 - ⇒ Stanadyne
 - ⇒ Diesel Kiki
 - ⇒ Zexel

Two Basic types of Fuel injection systems

- ⇒ Group 2
- ⇒ A gear- or cam driven low-pressure pump, which supplies fuel to each cylinder's unit injector

- ⇒ Types of Group 2 injection systems
- ⇒ Caterpillar
- ⇒ Cummins
- ⇒ Detroit Diesel

GOVERNORS

- ➡ A device used to limit high- and low-idle rpm and/or maintain a selected uniform rpm within the power range of the engine

GOVERNORS

- ⇒ Diesel engine can accelerate at a rate of more than 2,000 revolutions per second
- ⇒ A fast acting governor must control against the engine over speeding

Numerous types of Governors

⇒ Different types of governors

- Mechanical
- Pneumatic
- Servo
- Hydraulic
- Electronic

Fuel Injection Nozzles

- ➡ The purpose of the injection nozzle is to direct and atomize the metered fuel into the combustion chamber.

Fuel injection Nozzle

- ➡ The combustion chamber design dictates the type of nozzle, the droplet size, the spray pattern, and the spray angle required to achieve complete combustion within a given time and space.

Fuel Injection Nozzle

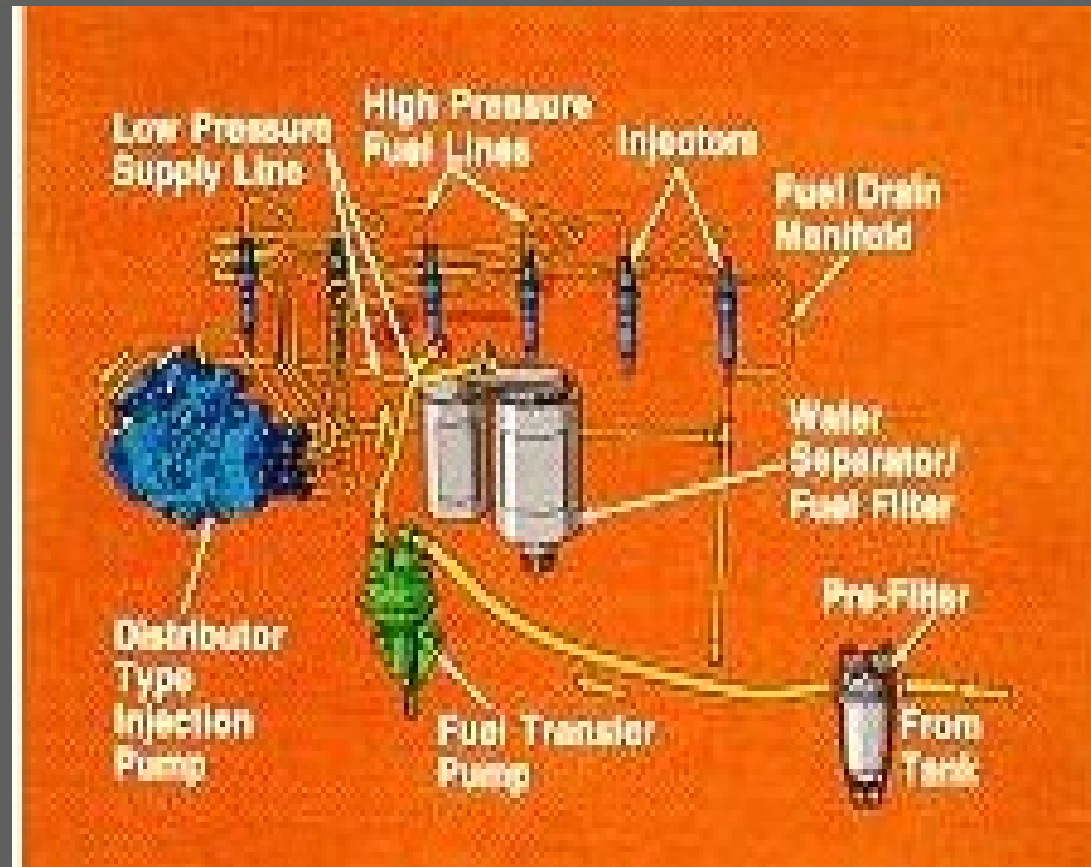
- ➡ Each injection nozzle is identified by a lettering and/or numbering system to identify the nozzle design, dimensions, spray angle in degrees, hole size, number of holes, sac hole size, and valve lift.



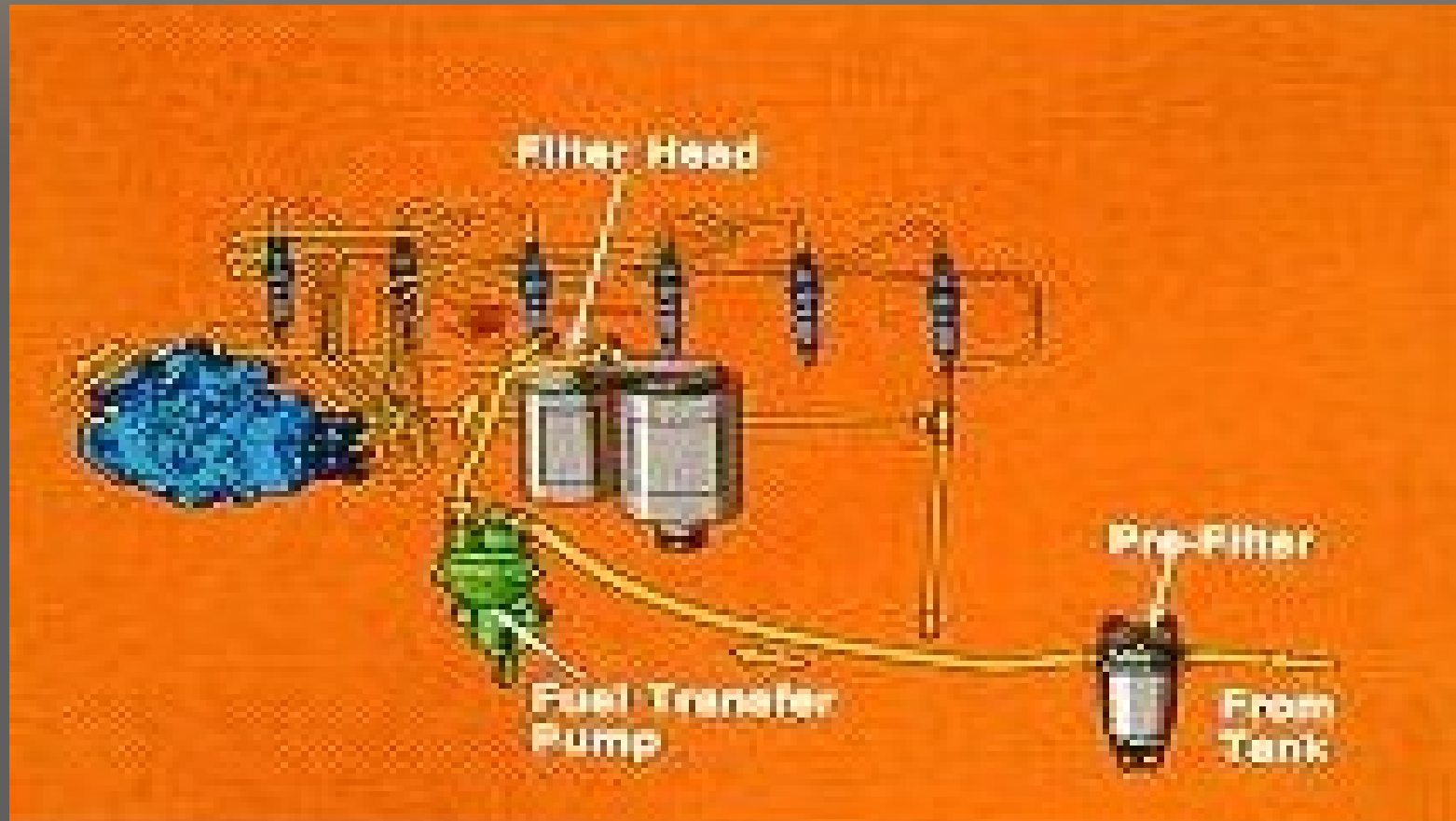
Take a 10 min Break

Cummins Distributor Fuel System

- ➔ Operation of the fuel system in order of fuel flow to the injection pump and component operation

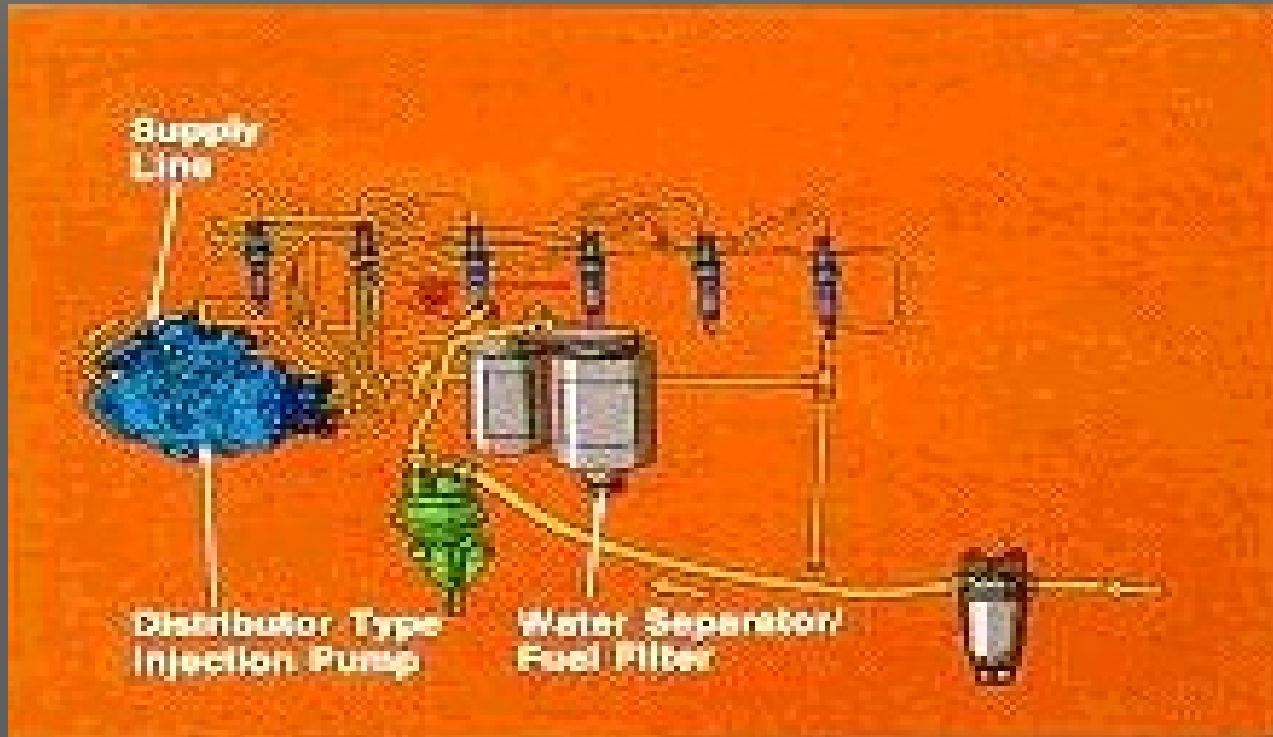


Fuel Transfer pump



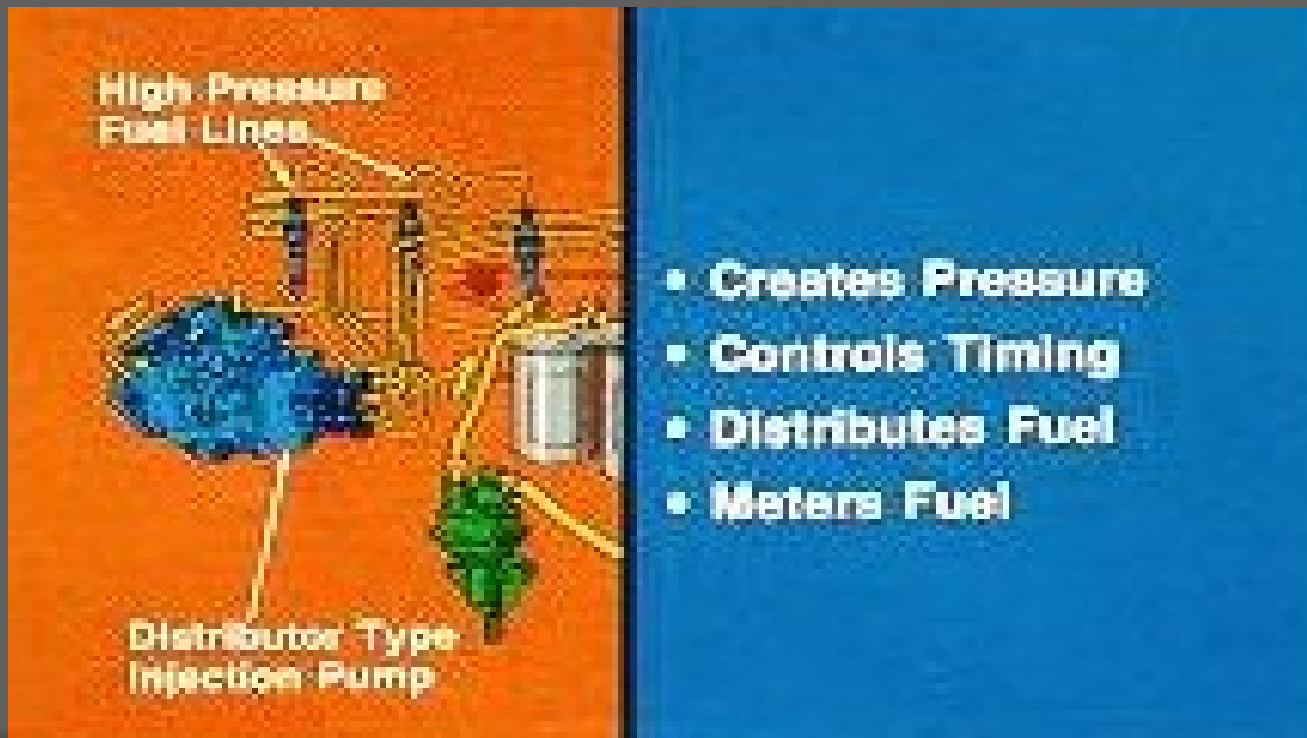
The fuel transfer pump draws fuel from the supply tank, through a prefilter or screen, to provide positive fuel flow to the filter head. The prefilter removes particles from the fuel larger than 140 microns, which can block the

Flow from tank

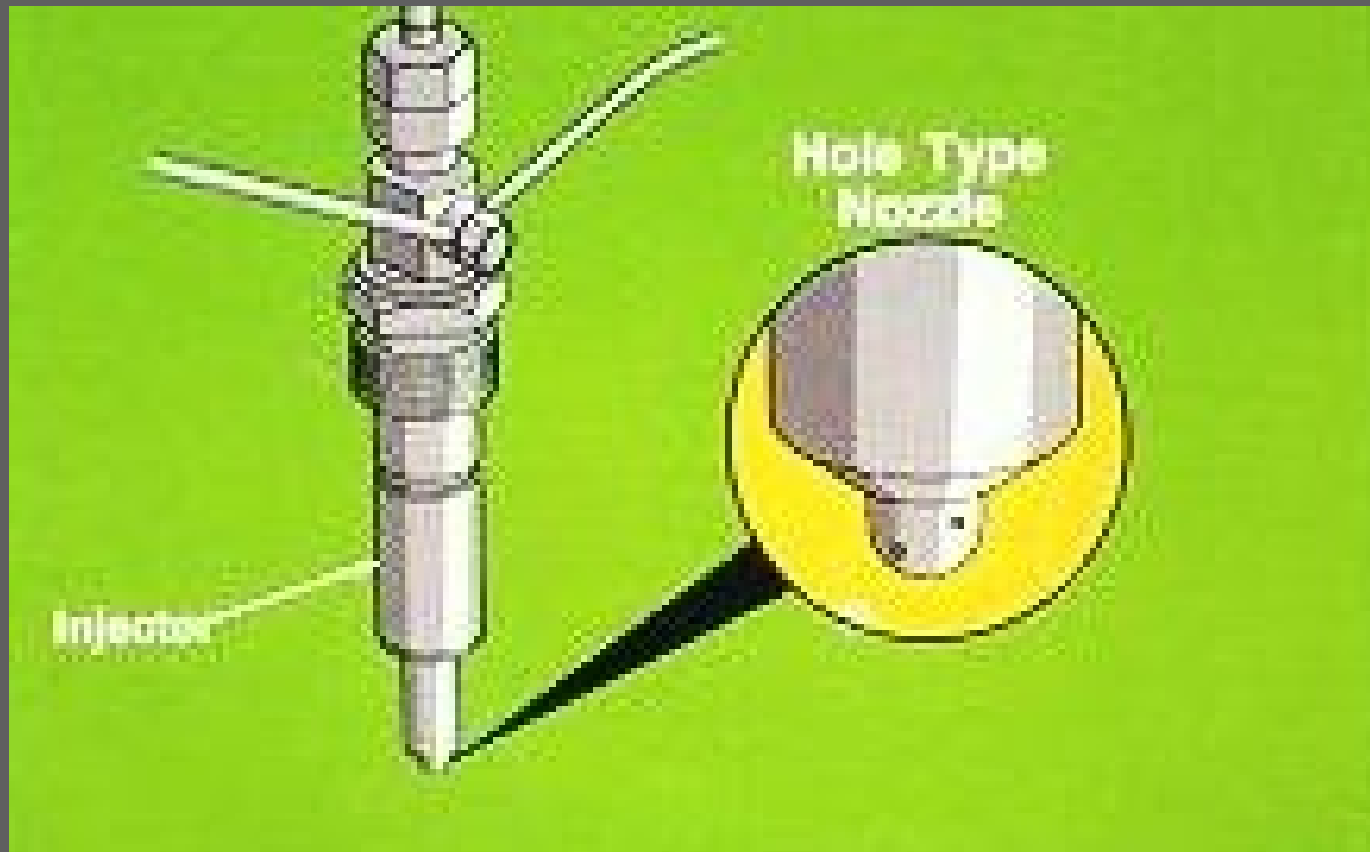


- ➡ Fuel flows through the filter head into the combination water separator and fuel filter, where water and contaminants are removed. Filtered fuel is transferred to the distributor pump through the supply line

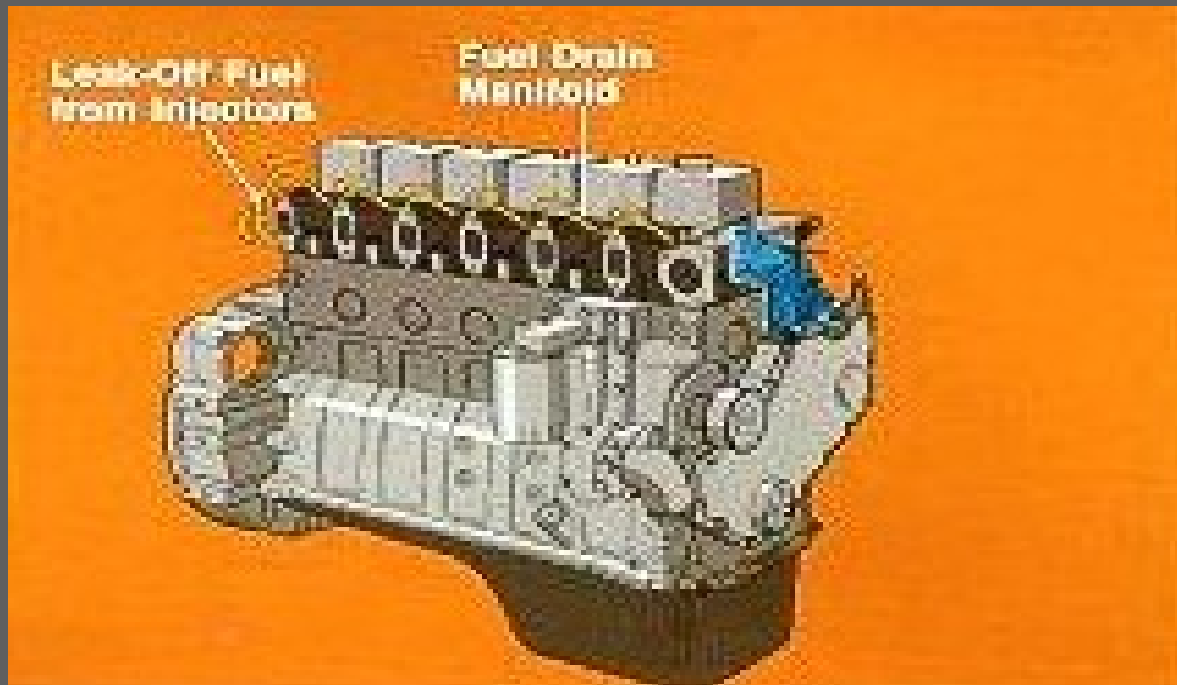
- The distributor pump pressurizes, controls timing, distributes and meters an amount of high-pressure lines (one line per cylinder)



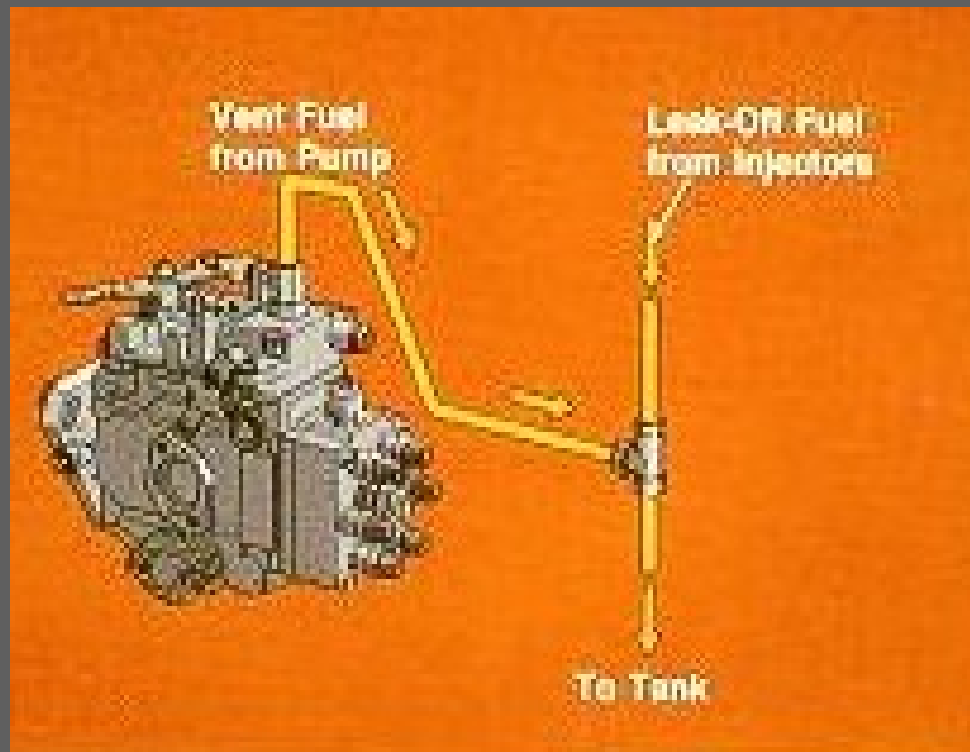
- During injection, the pressurized fuel is forced through spray holes in the injection nozzle causing atomization of the fuel for combustion.
- Hole type nozzles are used on the B series engines.



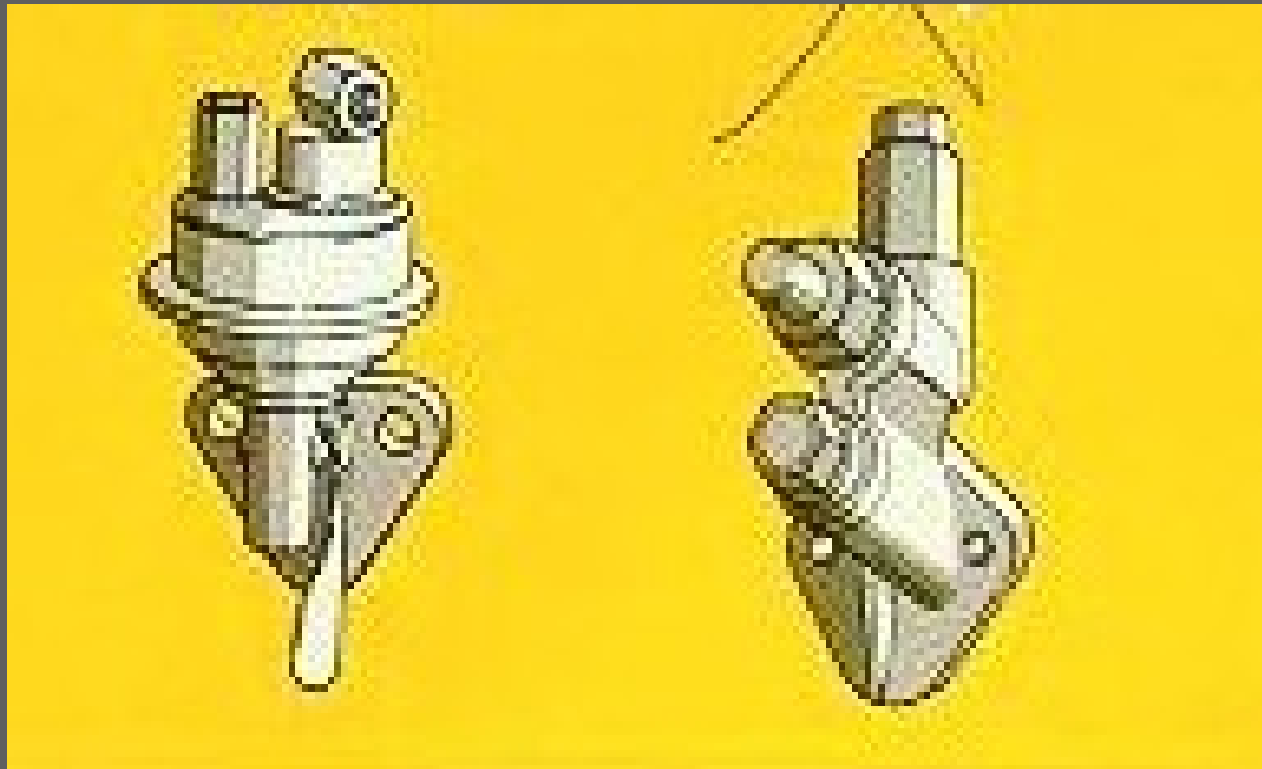
- ➔ A small amount of leak-off fuel from the injectors



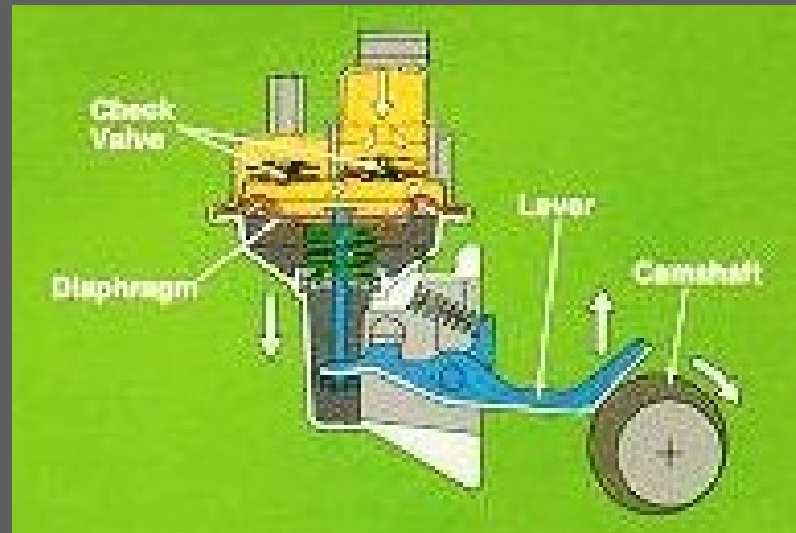
Fuel vented from the injection pump flows back to the tank



- The Cummins B series engine uses a standard diaphragm type fuel transfer pump or an optional plunger type pump.
- Both fuel transfer pumps are driven by a special lobe on the camshaft.

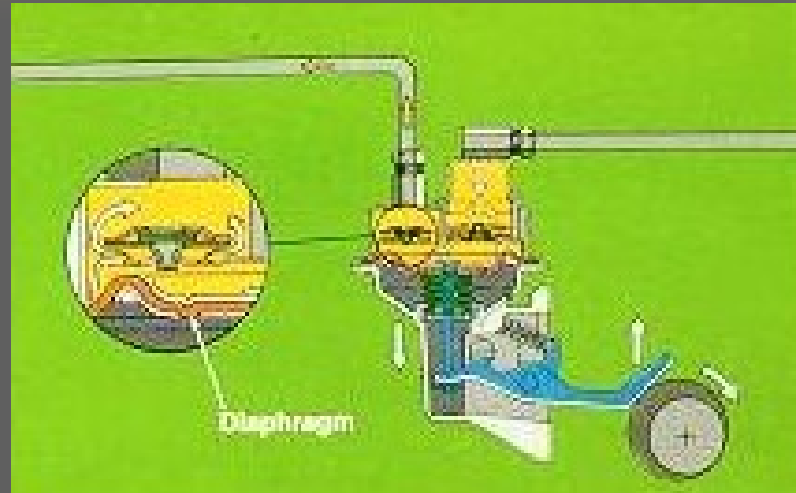


Fuel pump operation



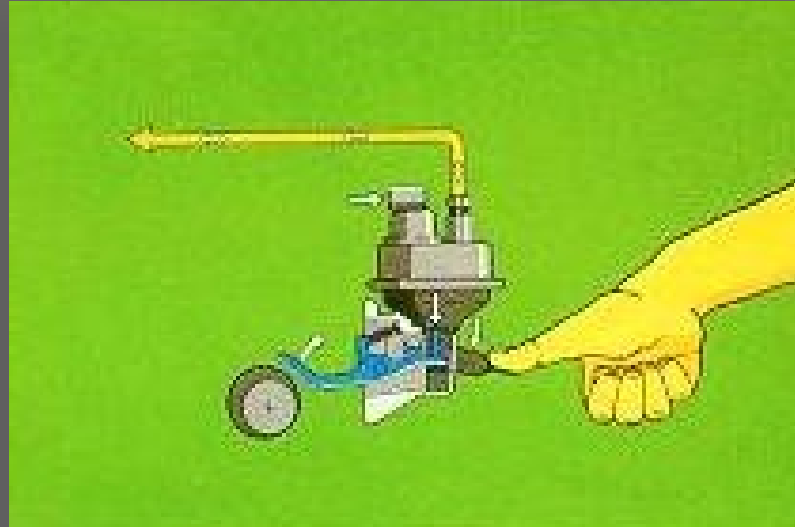
- ➔ A cam lobe raises the arm on the diaphragm style fuel transfer pump to create the pumping action.
- ➔ All of the fuel transfer pumps use check valves to control the fuel flow.

Fuel pump Operation



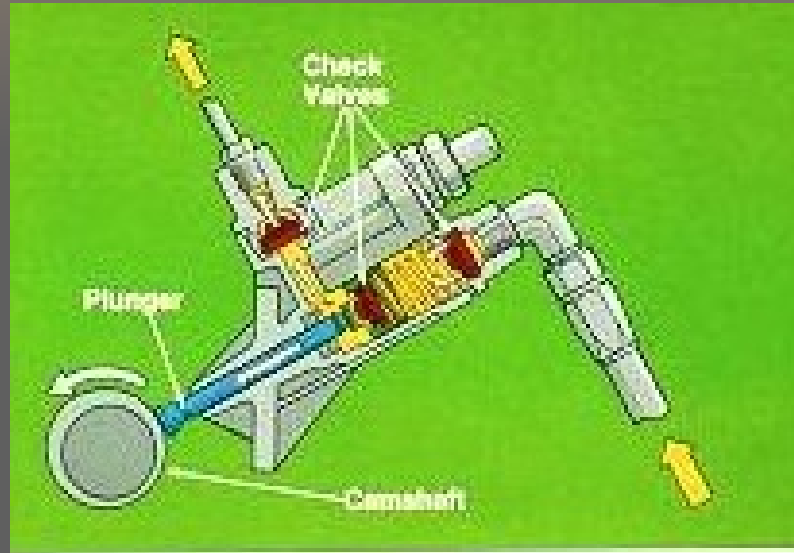
- A spring loaded diaphragm is used to move the fuel.
- Check valves prevent fuel bleed back during pumping and engine shutdown.

Fuel pump operation



- ➡ The diaphragm pumps have an external lever to permit manual operation of the pump for priming.

Plunger type fuel transfer pump



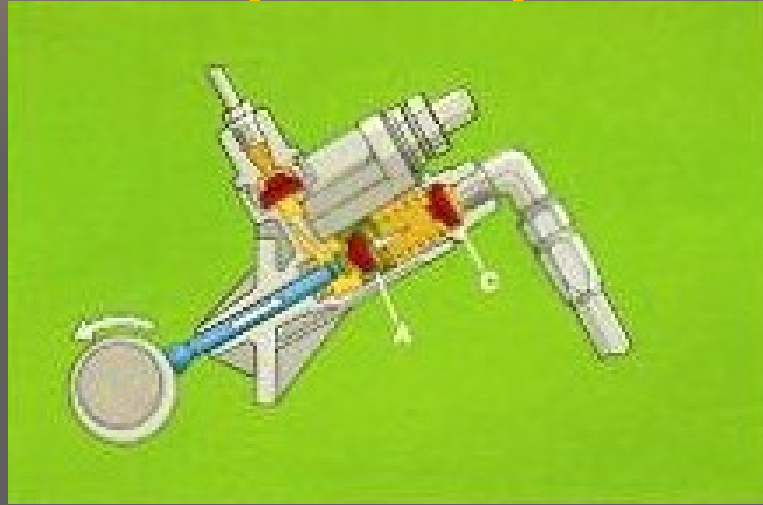
- The plunger type fuel transfer pump is mechanically-driven by a special lobe on the camshaft.
- The lobe pushes against the plunger in the fuel transfer pump to create pumping action.
- Check valves control the direction of fuel flow, and prevent bleed back during engine shutdown.
- The pump can be disassembled for cleaning and repair.

Plunger type fuel transfer pump



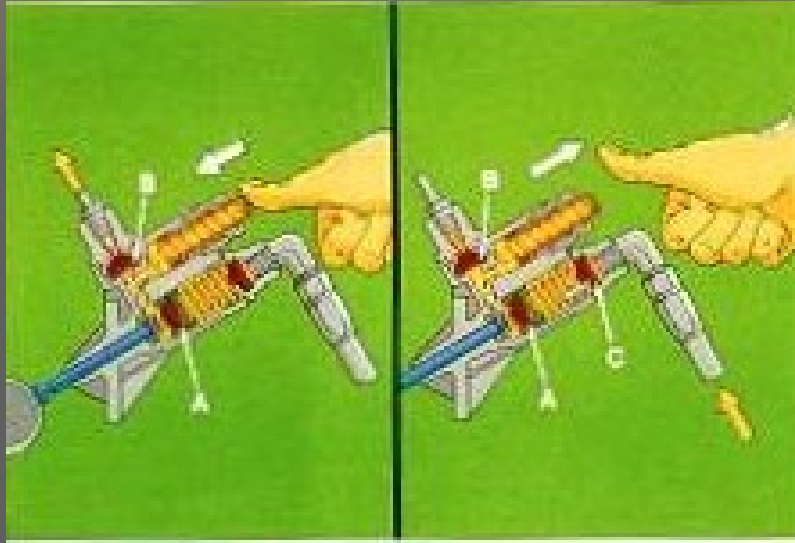
- As the high point on the cam rotates away from the fuel transfer pump, the spring forces the piston toward the camshaft.
- The pressure of the fuel in the piston bore closes check valve (a) and opens check valve (B), and fuel is forced to the low-pressure supply line.
- As the piston moves, check valve (C) opens and fuel is drawn into the spring cavity.

Plunger type fuel transfer pump



- As the high point of the cam rotates toward the fuel transfer pump, the plunger and piston are forced toward the inlet.
- The pressure of the fuel on the spring side of the piston causes check valve (C) to close and check valve (A) to open, allowing the fuel in the spring cavity to flow to the other side of the piston.

Plunger type fuel transfer pump



- A second plunger allows manual priming and bleeding of air from the system.
- When the plunger is depressed, check valve (A) prevents back flow and fuel is forced through check valve (B).
- When the plunger is released, the spring forces the plunger outward.
- This action creates suction that causes check valve (B) to close.
- At this time, the suction draws fuel through open check valves (A) and (C).

Plunger type fuel transfer pump

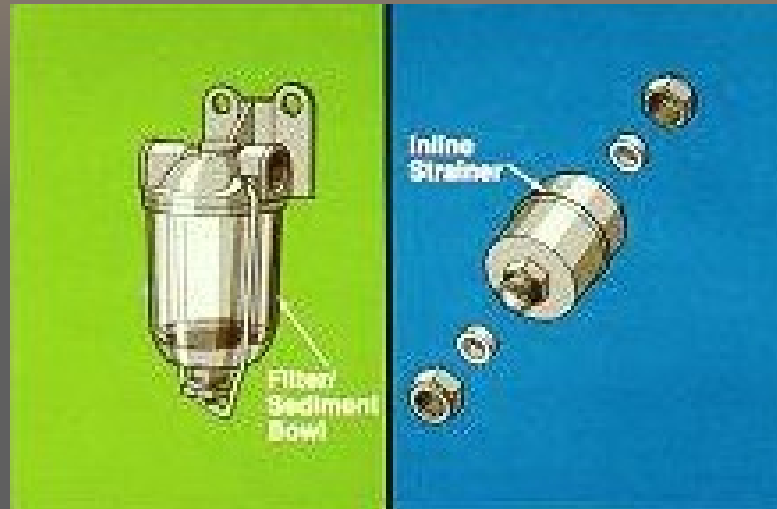


- ➡ It should be understood that the fuel transfer pump will not function if the valves are blocked open from particles in the fuel. Don't operate without filter or screen.
- ➡ The volume pumped by the fuel transfer pump will vary with engine speed, but should always provide excess flow, which is returned to the supply tank from the vent fitting on the injection pump.

Filtration

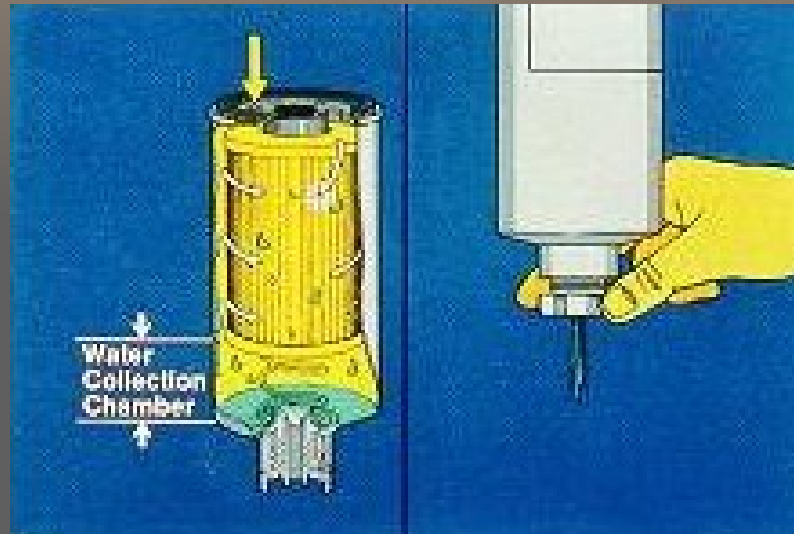
- ➡ Fuel-water separation and filtration is the key to trouble free operation and long life of the fuel system.
- ➡ Some of the clearances between pump parts are very close.
- ➡ For this reason the parts may easily be damaged by rust formation and contaminants.

Filtration



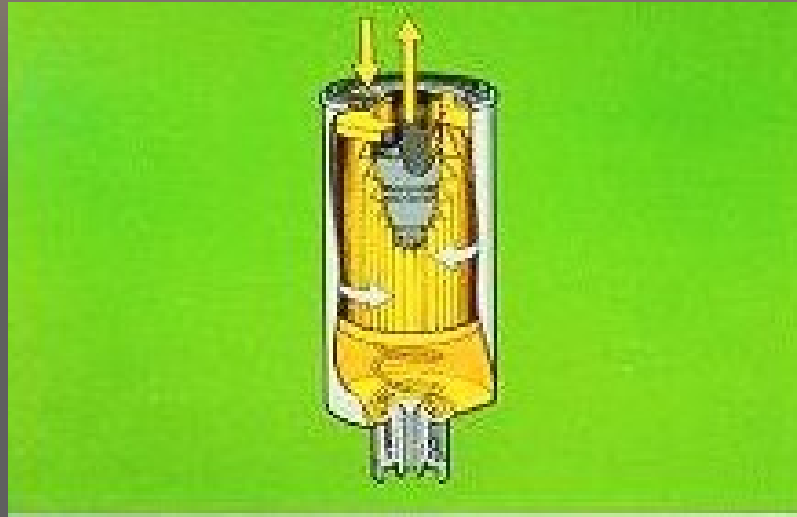
- ➡ Between the supply tank and the fuel transfer pump the fuel flows through a filter/sediment bowl or an inline strainer which protects the fuel transfer pump from debris.

Filtration



- ➡ With the dual filter arrangement, the fuel flows through the first filter, and moisture precipitates down the collection chamber.
- ➡ The OPERATOR must drain the water regularly by opening the valve.

Filtration



- ➡ The filter element removes other contaminants from the fuel.
- ➡ Good filtration is required to protect the internal components of the fuel system

Filtration



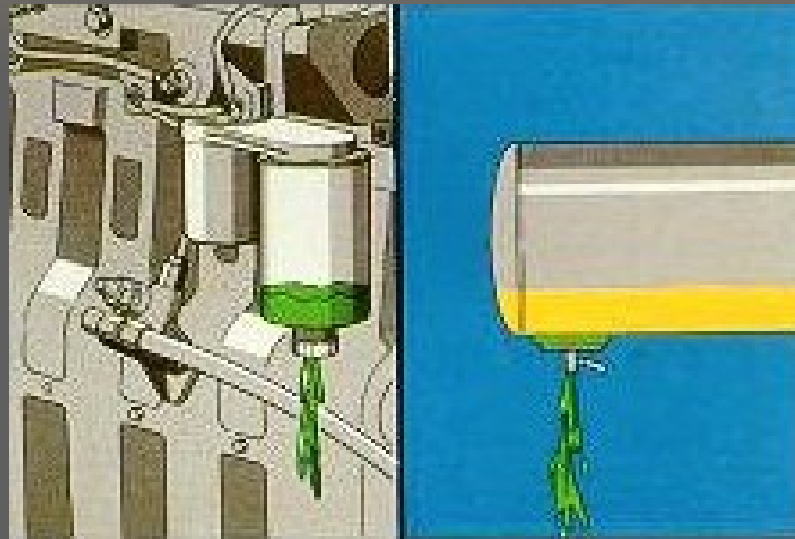
- The second filter in the dual filter arrangement provides additional protection against damage to the pump.
- Square cut sealing rings are used for sealing between the mating surfaces.
- A large sealing ring is affixed to the fuel filter seals the outside diameter.
- A smaller sealing ring seals the inside diameter around the threaded support.



Filter pressure

The Maximum allowable pressure drop across the filters is 5 PSI.

Filter Maintenance

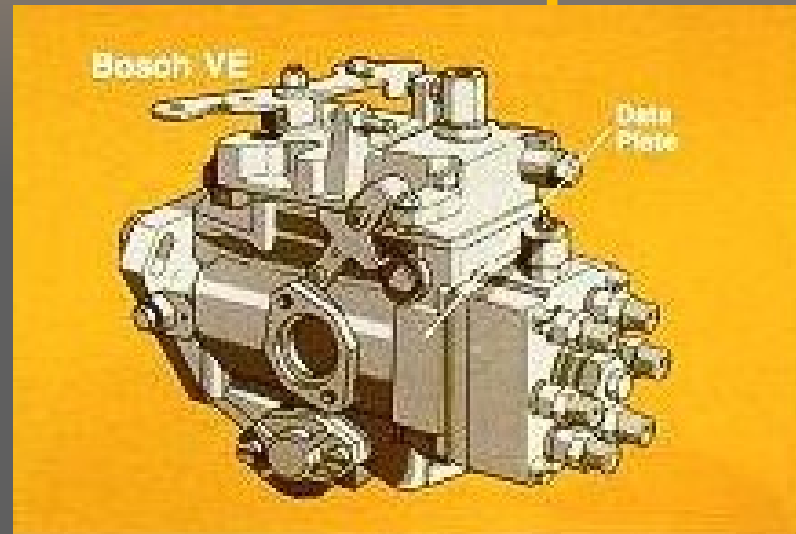


- ➡ Regular maintenance, including draining moisture from the water separator/fuel filter and supply tanks, is essential to keep water out of the fuel.

From Filter to the Injection Pump

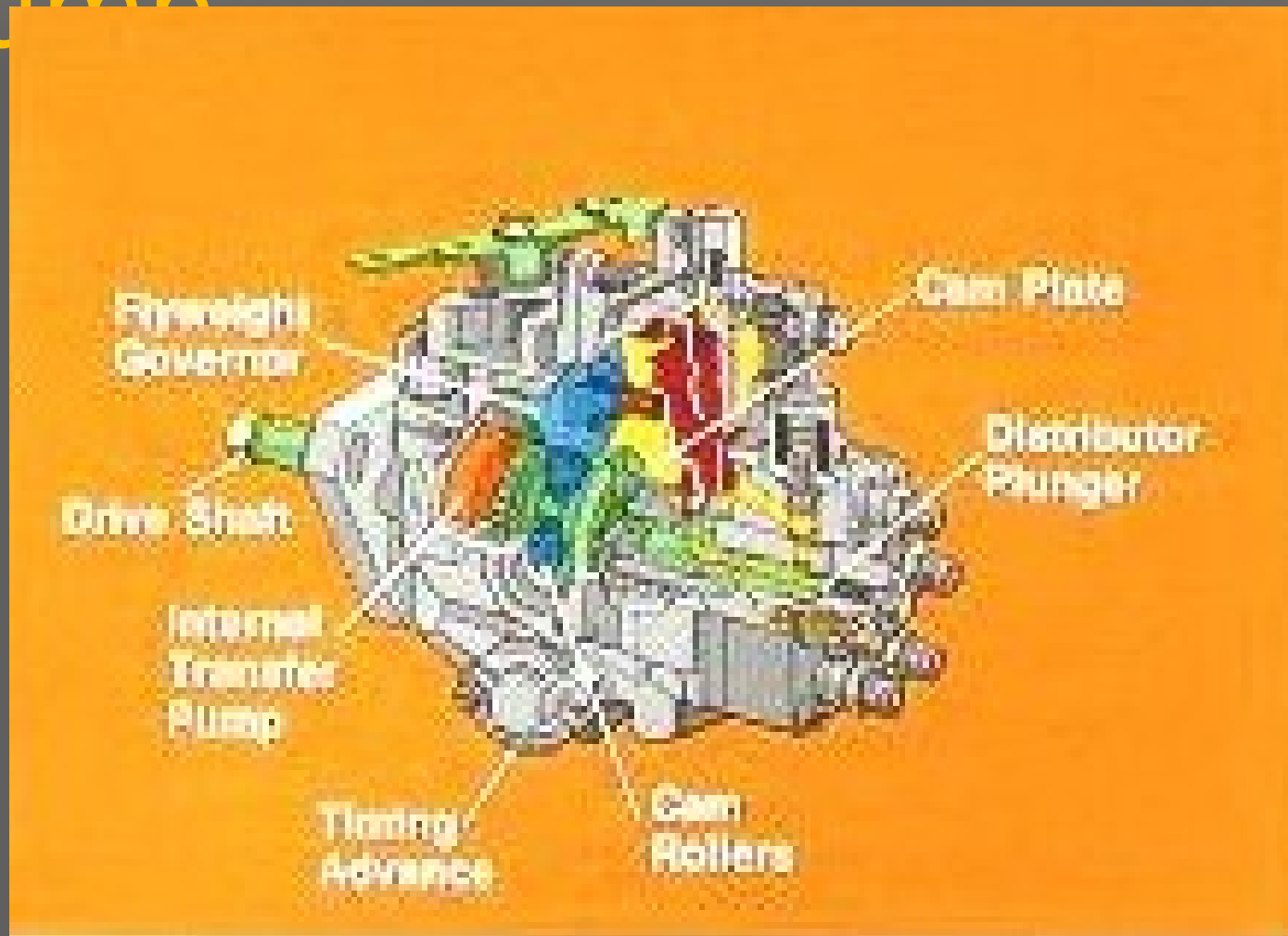
- ➔ The low pressure supply line conveys fuel from the injection pump inlet fitting.
- ➔ The fuel pressure in the line will normally not exceed 20 PSI.
- ➔ A vent fitting on the injection pump opens at that pressure to regulate supply line pressure.

Bosch Model VE Injection Pump

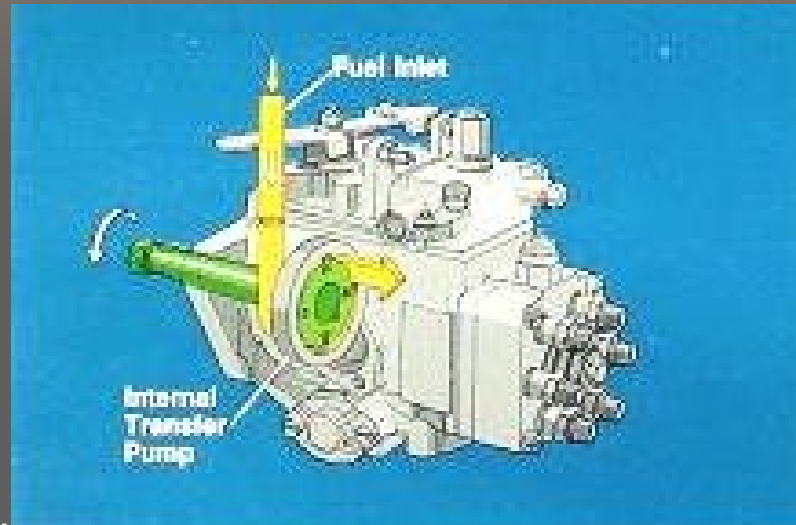


- The Bosch model VE injection pump is a mechanically governed, distributor injection pump.
- The data plate provides important information about configuration and specifications for the pump, including serial number.

Bosch Model VE injection Pump

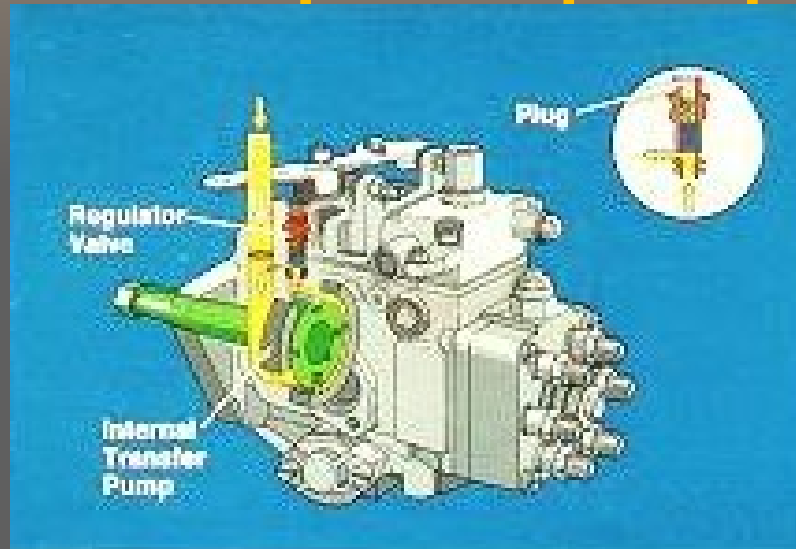


VE injection pump



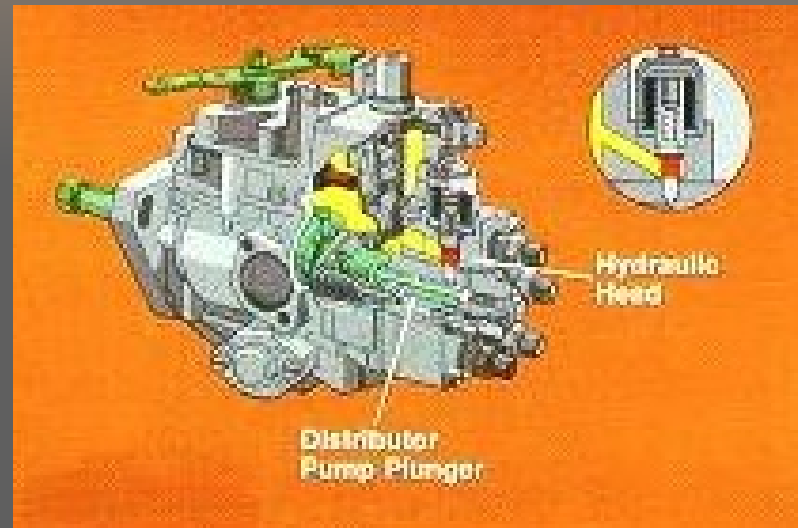
- Distributor injection pump operation begins with fuel entering the inlet port of the pump housing and the internal transfer pump.
- The internal vane type transfer pump is driven by the pump drive shaft.
- It transfers fuel, under pressure, to the distributor pump housing.
- The volume and fuel pressure of the internal transfer pump increases in relation to pump speed, up to a maximum of 115 PSU at rated speed.

Injection pump operation



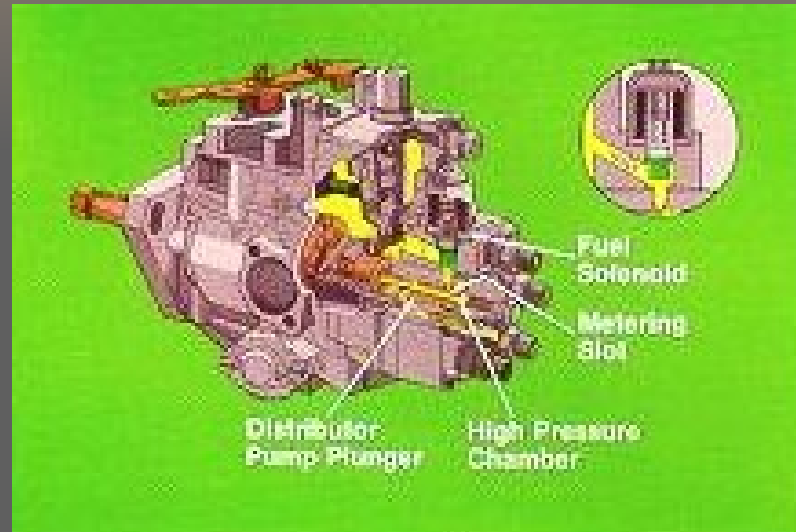
- ➔ The pressure regulator valve controls the internal pressure of the pump by allowing part of the fuel to be routed back to the inlet side of the internal transfer pump.
- ➔ The pressure is set by driving a plug against the spring to establish a spring force.
- ➔ An interface fit keeps the plug in position.

Injection pump operation



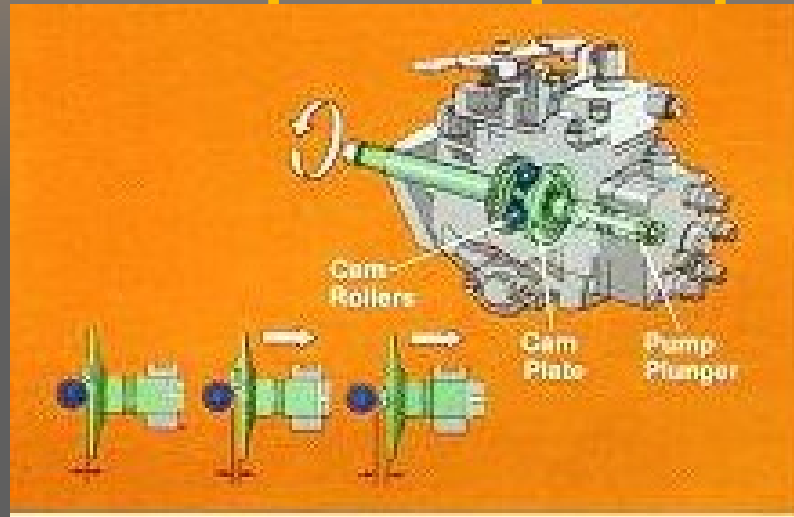
- ➡ Fuel, at internal pump pressure, fills the drilling in the hydraulic head.
- ➡ This drilling is the passage for the flow of fuel to the fuel solenoid valve.

Injection pump operation



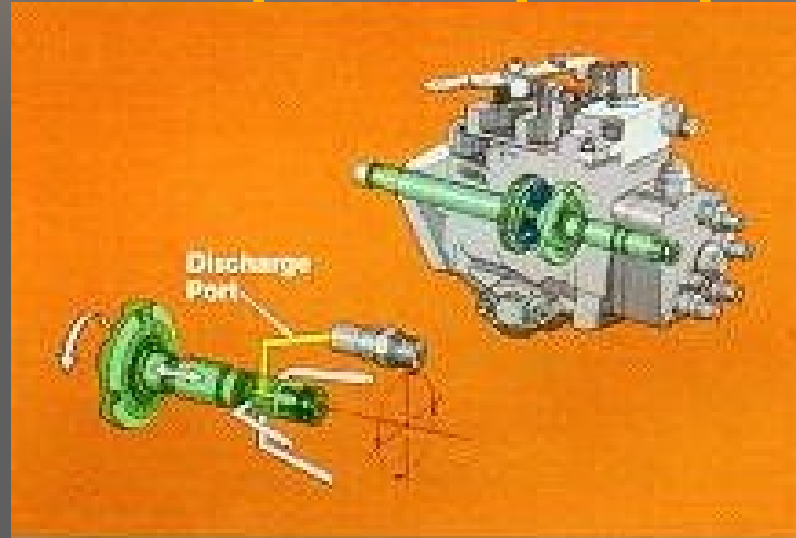
- ➡ When the fuel solenoid valve is open, the internal pump maintains a supply of fuel to the metering slot and the high pressure chamber; which is at the end of the distributor pump plunger.

Injection pump operation



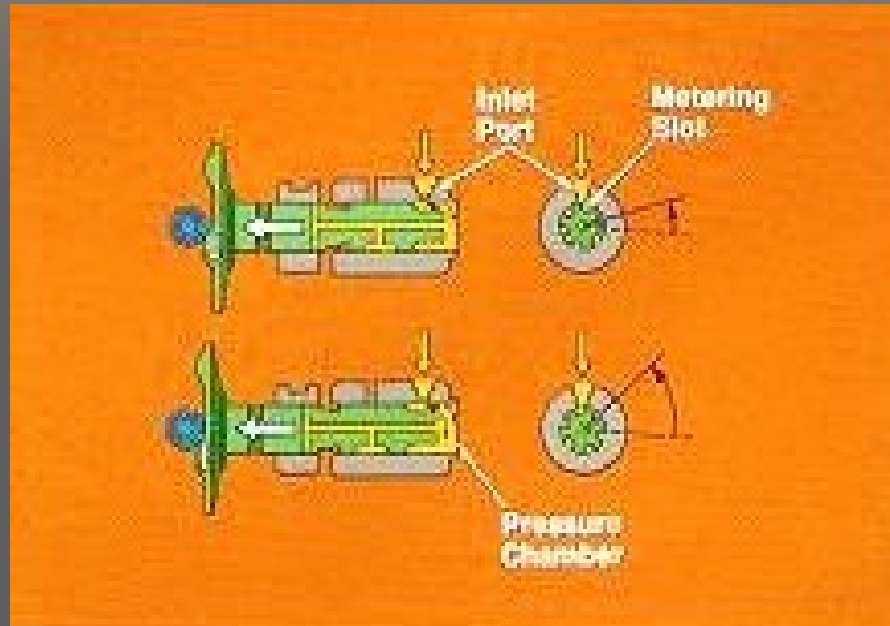
- ➡ The distributor pump plunger has a rotary and linear motion.
- ➡ The rotary motion is produced by the rotation of the drive shaft
- ➡ The linear motion is produced by the cam plate as the cam lobes rotate against the stationary cam rollers

Injection pump operation



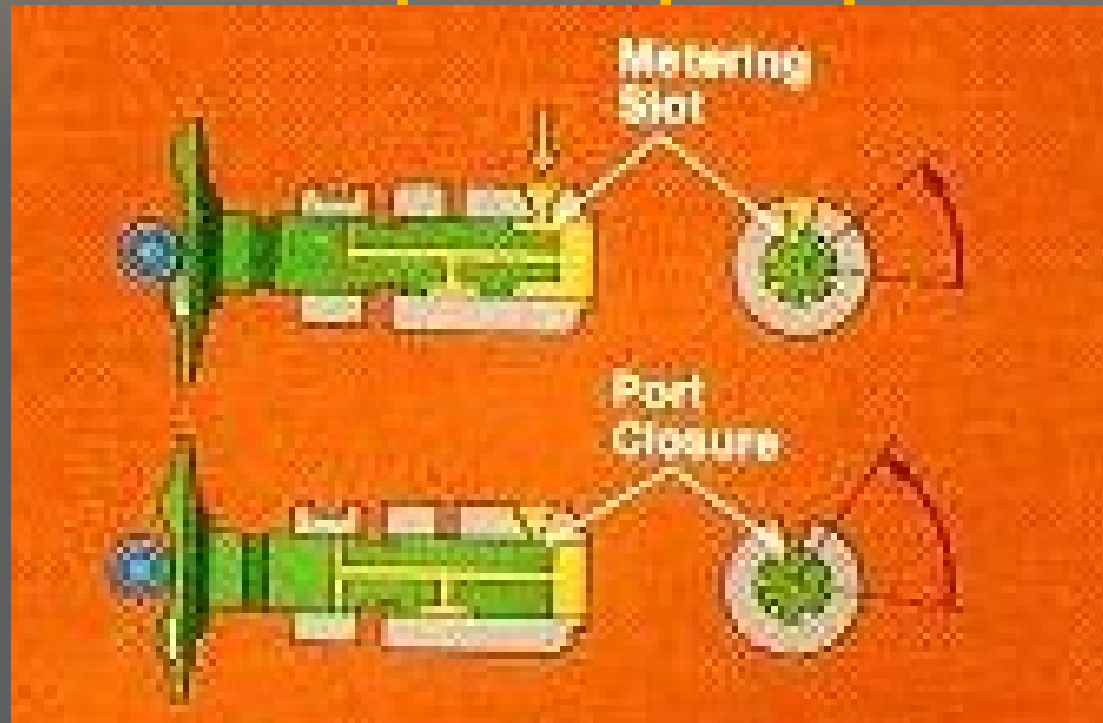
- ⇒ The rotary-linear motion of the distributor pump plunger has two functions.
- ⇒ To develop the injection pressure
- ⇒ Distribute the fuel to the appropriate engine cylinder through high-pressure lines.

Injection pump operation



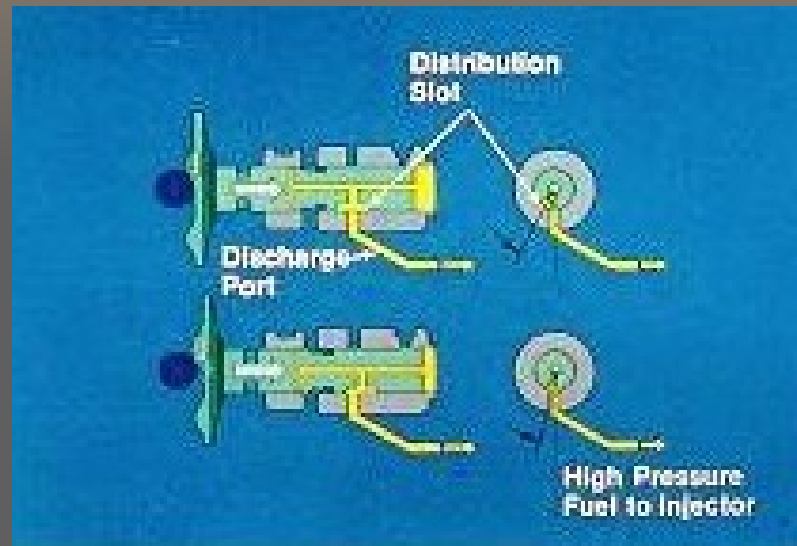
- ⇒ Charging or filling of the pressure chamber begins during the inlet stroke.
- ⇒ The cam plate allows the plunger to retract.
- ⇒ The metering slot is rotated to align with the inlet port and fuel fills the pressure chamber.

Injection pump operation



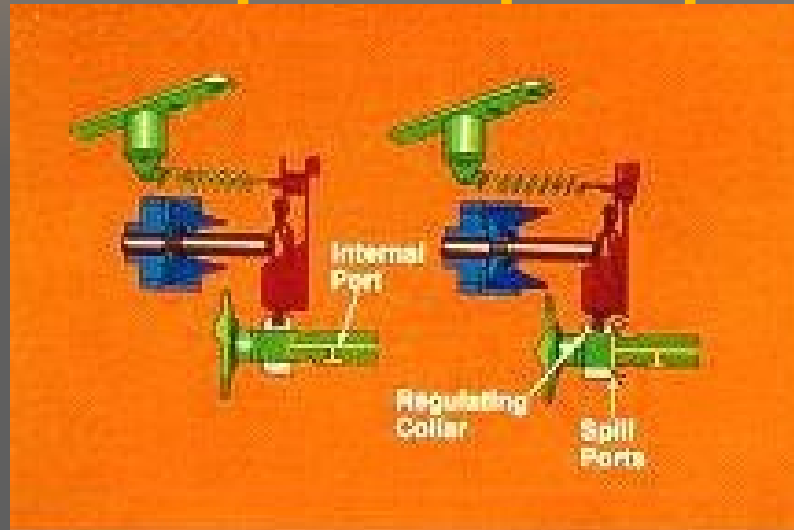
- ➔ Continuing plunger rotation moves the metering slot out of alignment with the inlet port.
- ➔ Port closure isolates the fuel in the pressure chamber

Injection pump operation



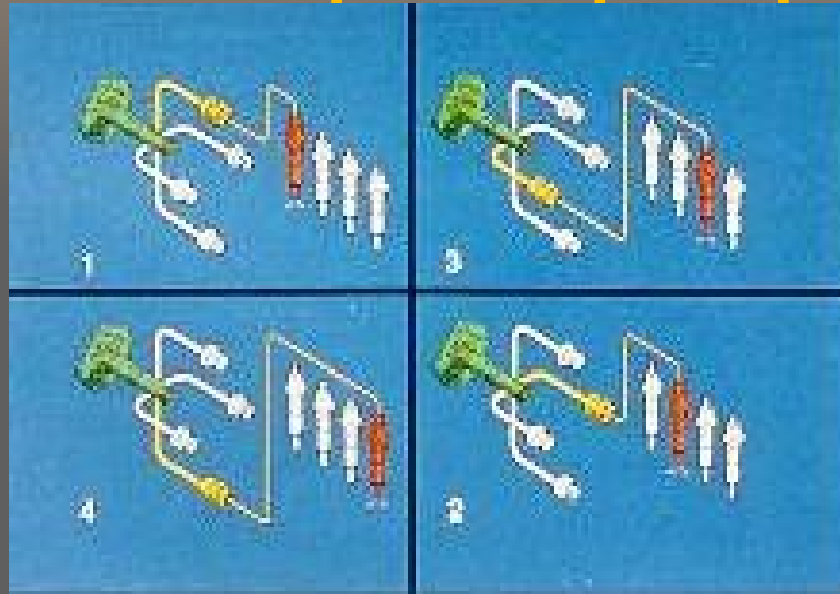
- The action of the cam plate causes the plunger to move towards the pressure chamber, increasing the pressure of the isolated fuel in the pressure chamber.
- As the plunger continues to increase the pressure in the chamber, the distribution slot aligns with one of the discharge ports and fuel is forced out to the injectors through the high-pressure lines.

Injection pump operations



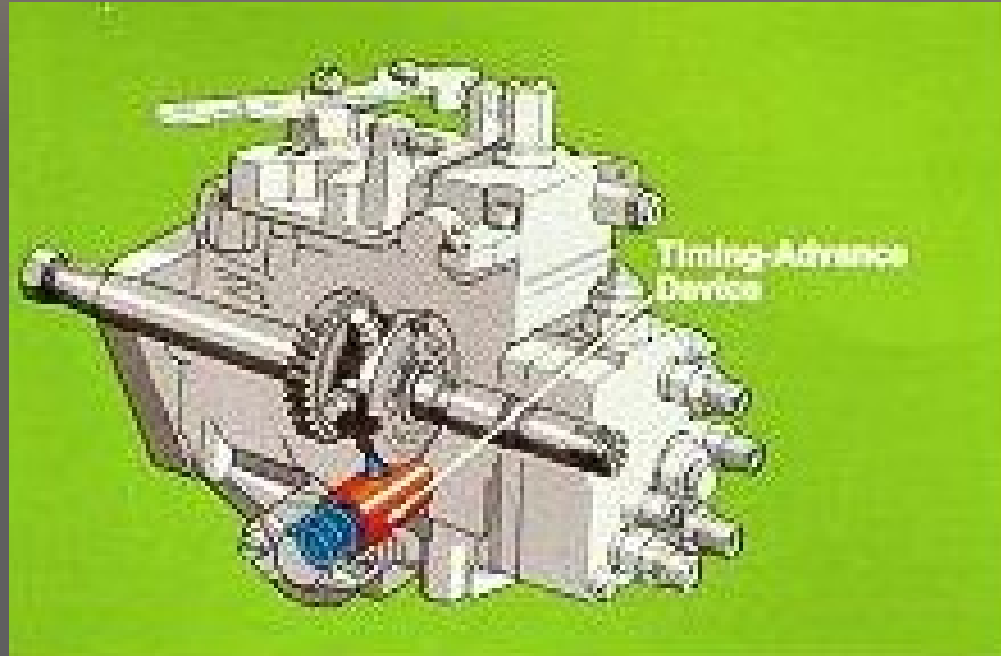
- ➔ The position of the regulating collar is controlled by the governor.
- ➔ The purpose of this collar is to regulate fuel volume delivered to the high-pressure lines.
- ➔ This is accomplished by opening the spill port, thereby allowing the fuel under pressure, in the internal port, to exit into the pump interior.

Injection pump operation



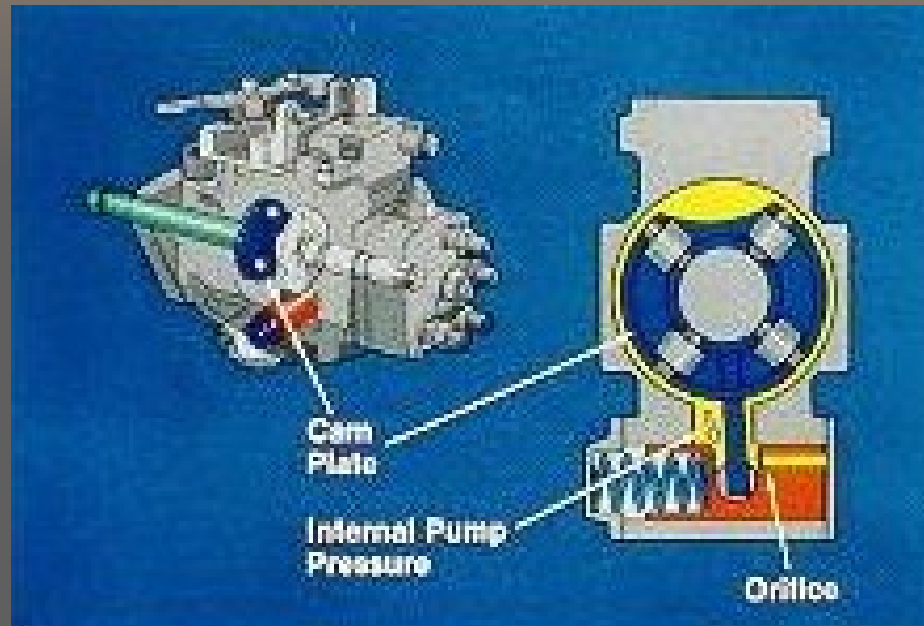
- Filling and injecting are repeated once for each discharge port per pump revolution.
- The pump is timed to the engine so that fuel injection occurs near the end of the compression stroke for each cylinder.
- Proper distribution is achieved by connecting the discharge ports to the cylinders according to engine firing order.

Injection pump operation



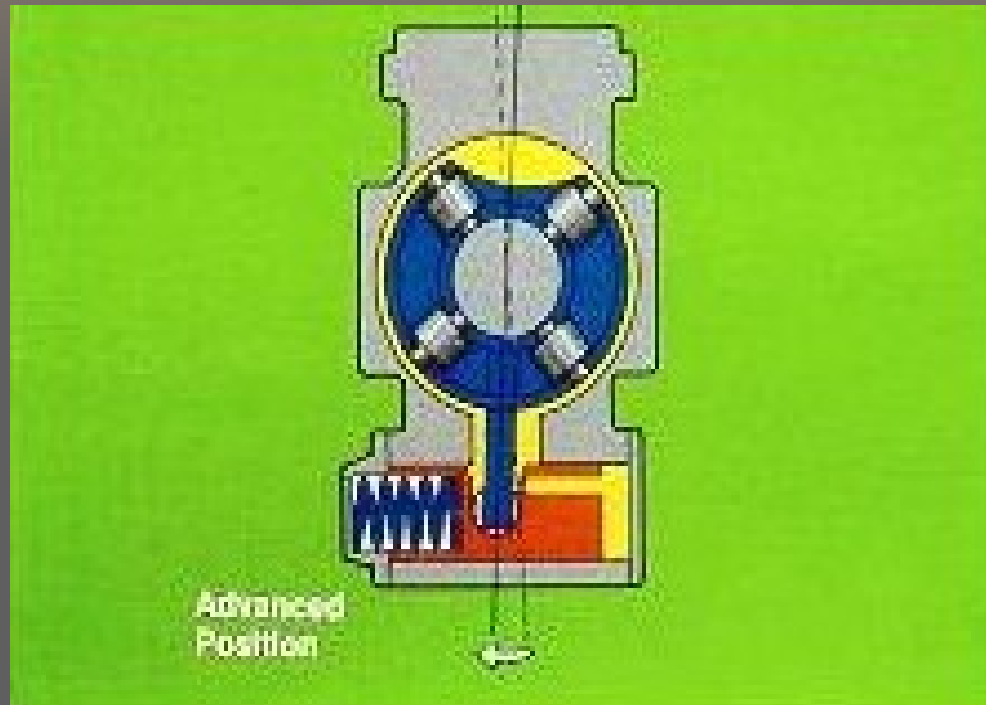
- ➔ In order to compensate for injection and ignition lag, the timing advance device advances the injection timing of the pump, relative to crankshaft position, as the engine speed increases.

Injection pump operation



- During cranking and idling, the cam roller ring is held in the starting position by the advance piston spring.
- As the engine speed increases, internal pump pressure increases and forces fuel through an orifice into the timing advance chamber.

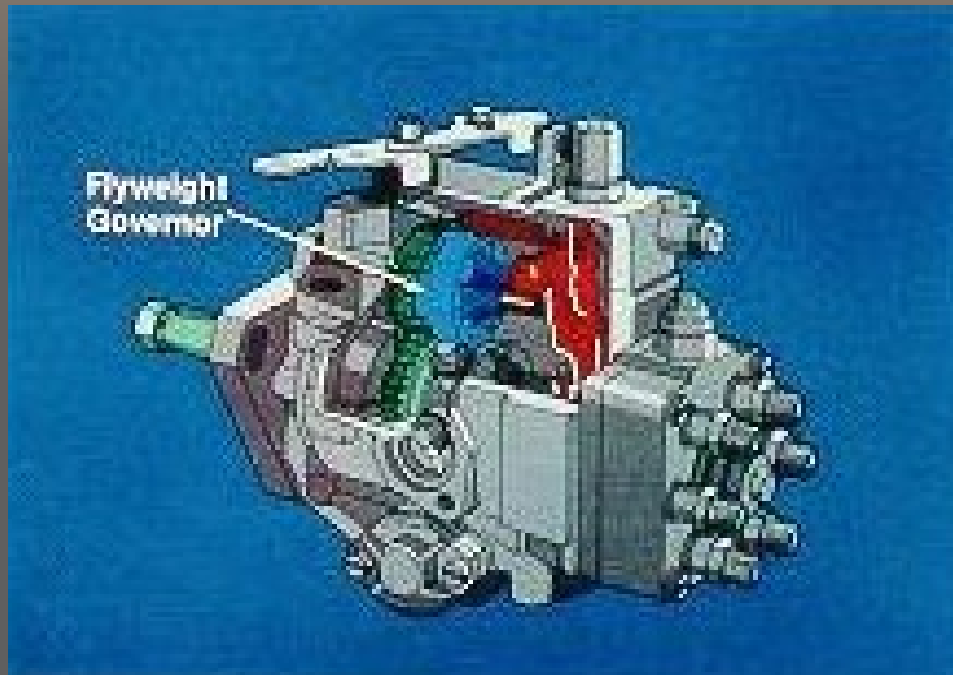
Injection pump operation



- ➡ This produces the force needed to move the piston against the spring and to advance the cam roller ring allowing the cam plate to contact the rollers sooner and initiate the injection cycle earlier.

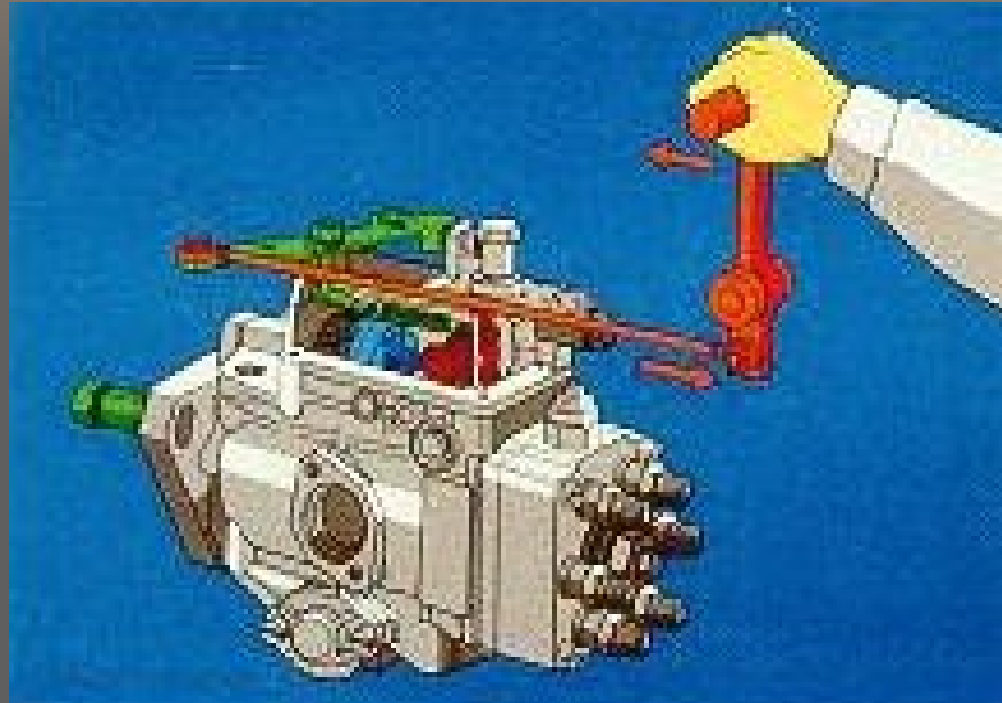
Governor

Governor



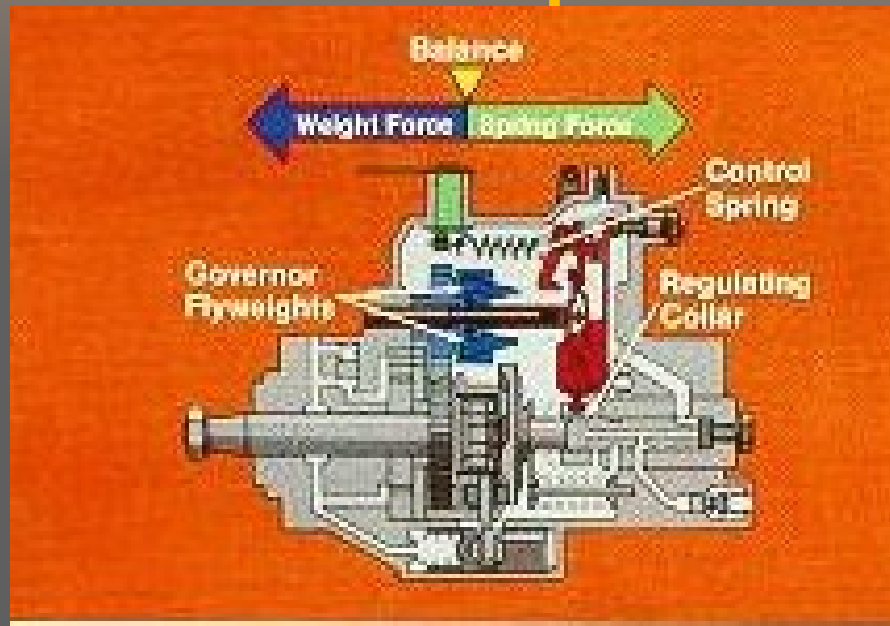
- The pump incorporates a mechanical flyweight governor, which is gear driven from the pump drive shaft.
- Springs and linkage are used to connect the governor to the engine throttle lever and regulating collar.

Governor operation



- ➔ The operator determines the desired speed between idle and governor break by moving the throttle lever.
- ➔ This establishes a spring force to oppose the centrifugal force of the flyweights, which positions the regulating collar.

Governor operation



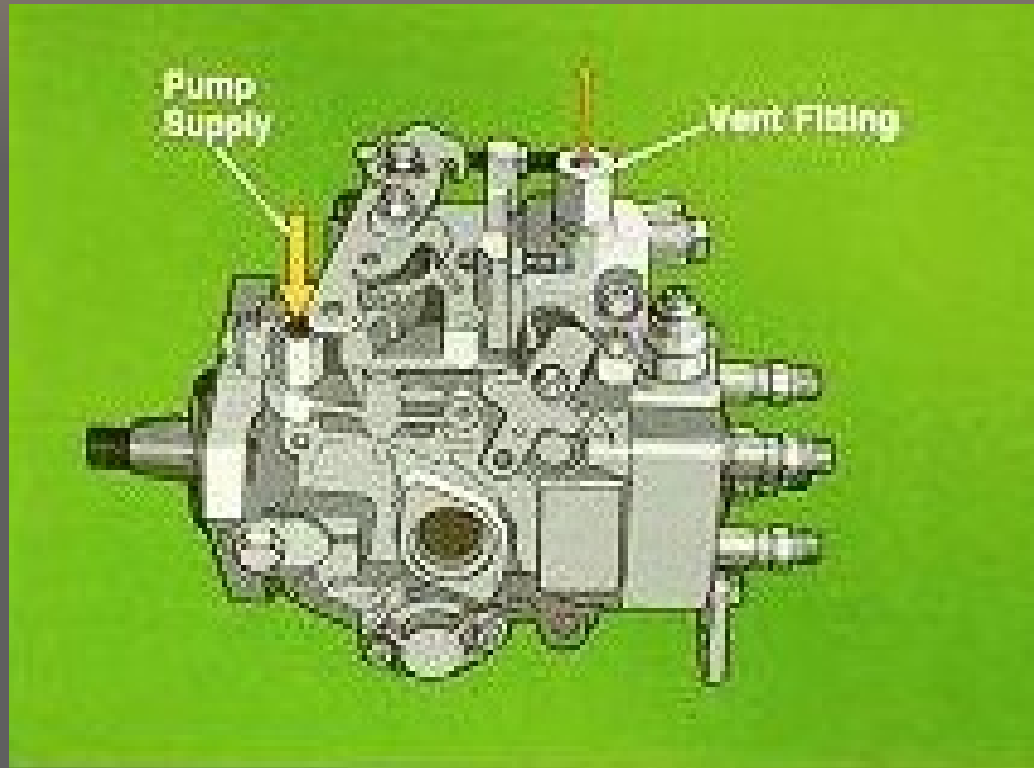
- ➔ When the engine reaches the speed corresponding to the throttle position, the two opposing forces are in balance.
- ➔ The regulating collar is now positioned to maintain a constant speed until engine loading or throttle position is changed.

Governor adjustment



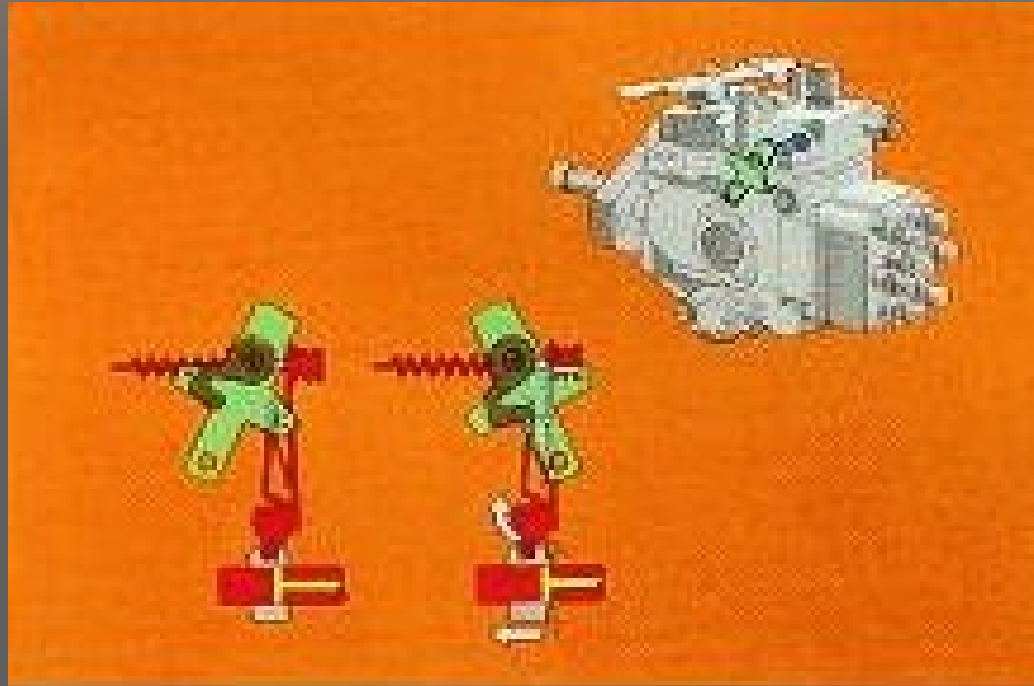
- ➡ The pump has external screws for limiting high idle and for setting the low idle speed.

Vent fitting



- ➡ The pump has a vent fitting which provides automatic bleeding and allows vented fuel to return to the supply tank.

Shut down lever



- The pump also has a mechanical shut down lever.
- When activated, the regulating collar holds the spill port open, thereby preventing the development of injection pressure.

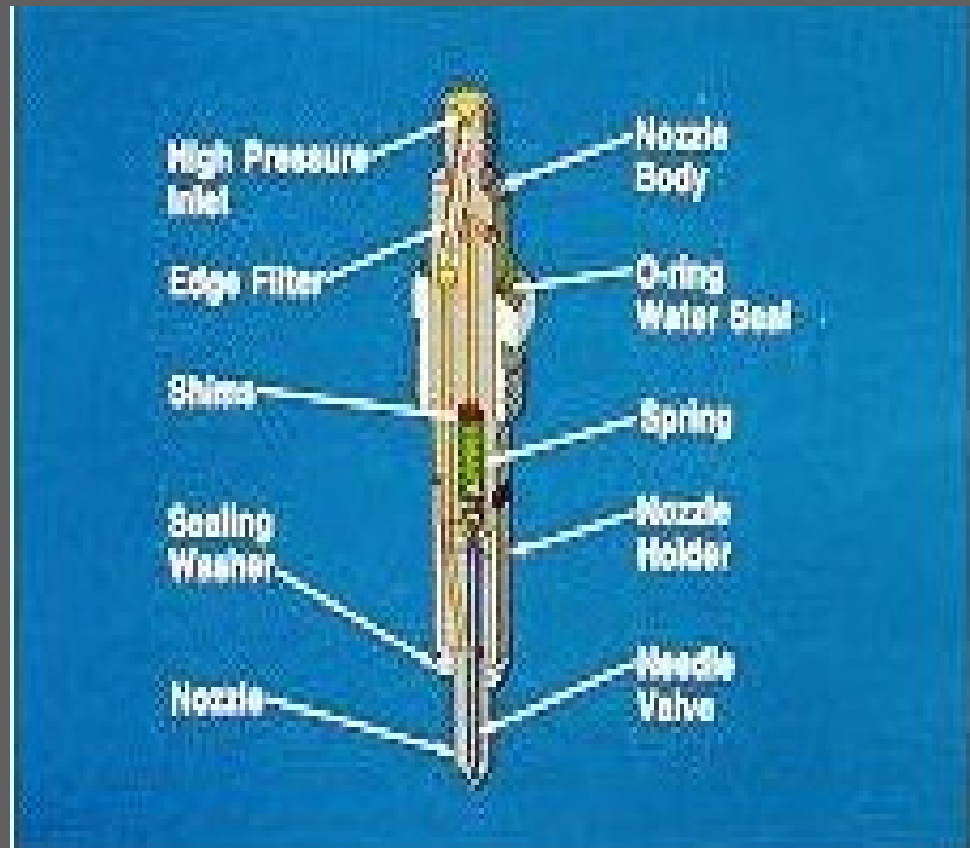


Injection Nozzle

The injection nozzle must inject an equal amount of fuel into each cylinder, atomize the fuel, and spread the fuel-spray to mix fully with the air for smooth operation.

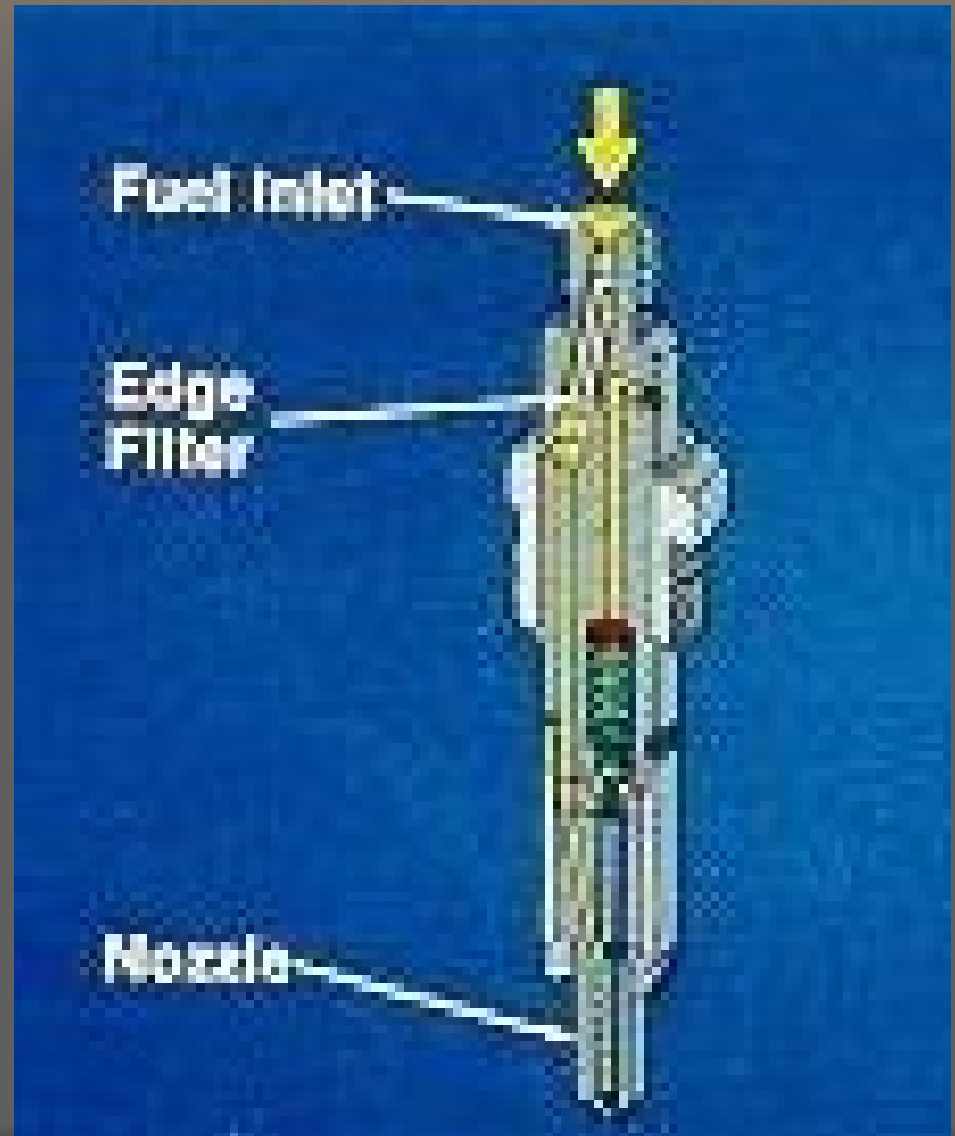
B Series Hole Type Injector

- ➡ The Cummins B Series uses a hole type injector
- ➡ The injector assembly consist of the:
 - Nozzle body
 - O-ring water seal
 - Spring
 - Nozzle holder
 - Needle valve
 - Nozzle
 - Sealing washer
 - Shims
 - Edge filter
 - High pressure inlet



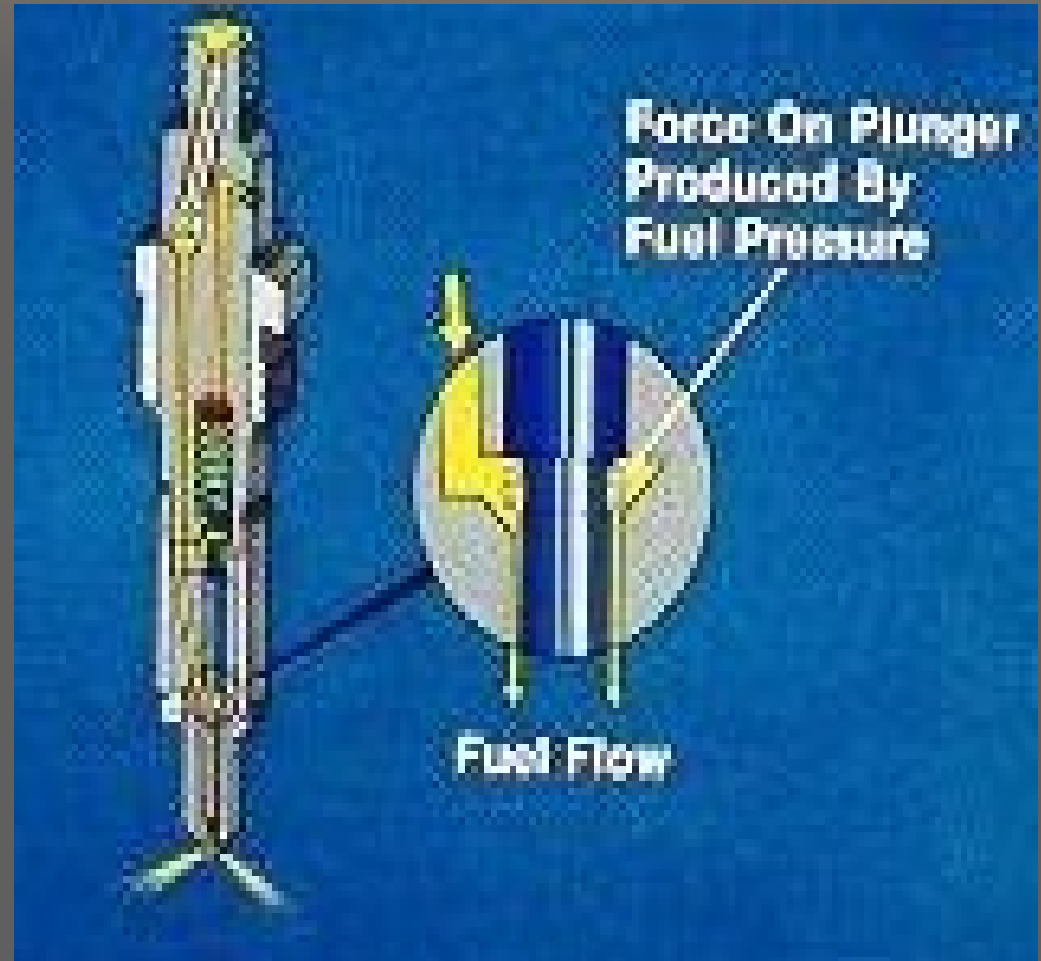
Hole type fuel injector

- ➔ During the injection cycle, high-pressure fuel from the pump is forced across the edge filter, down the drilling in the nozzle holder and nozzle, and enters the needle valve bore.



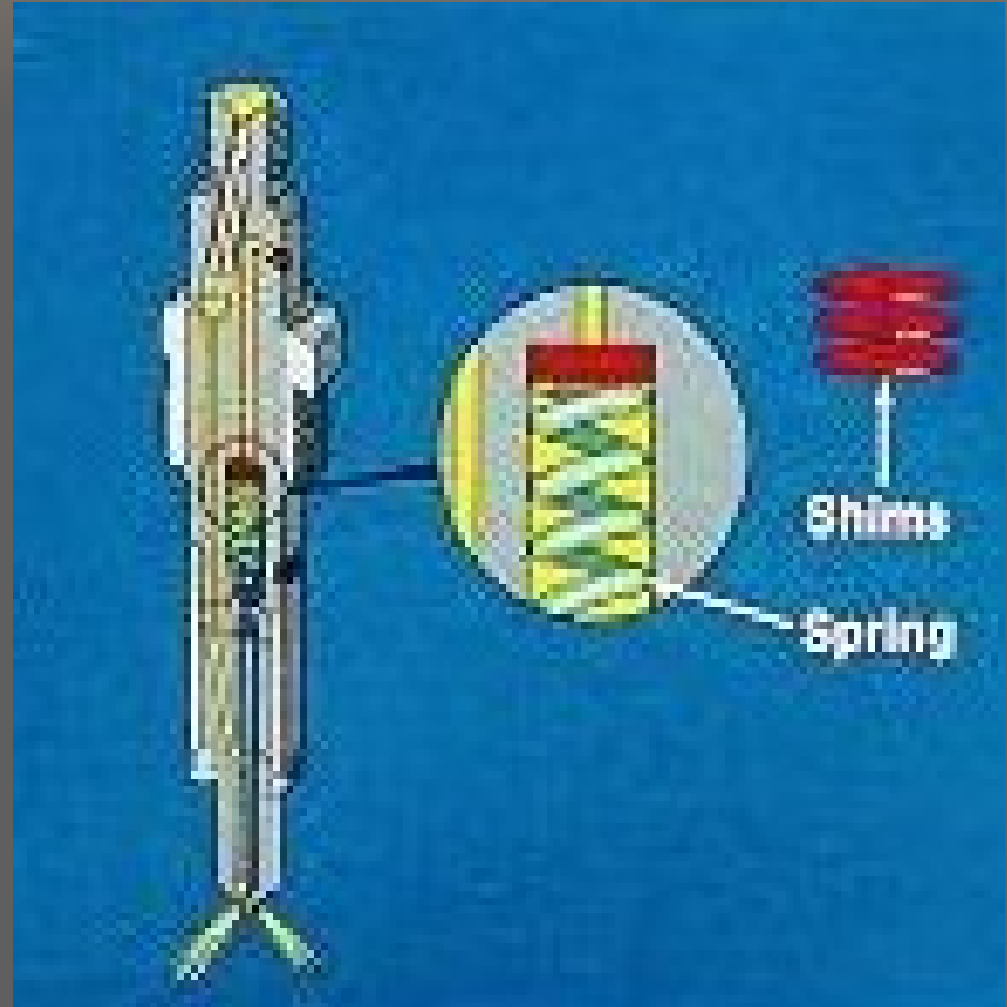
Hole type fuel injector

- ➡ The spring load on the needle valve keeps the valve closed until the pressure rises to approximately 3600 PSI.
- ➡ At this pressure, the valve lifts to allow fuel to flow into the nozzle tip.



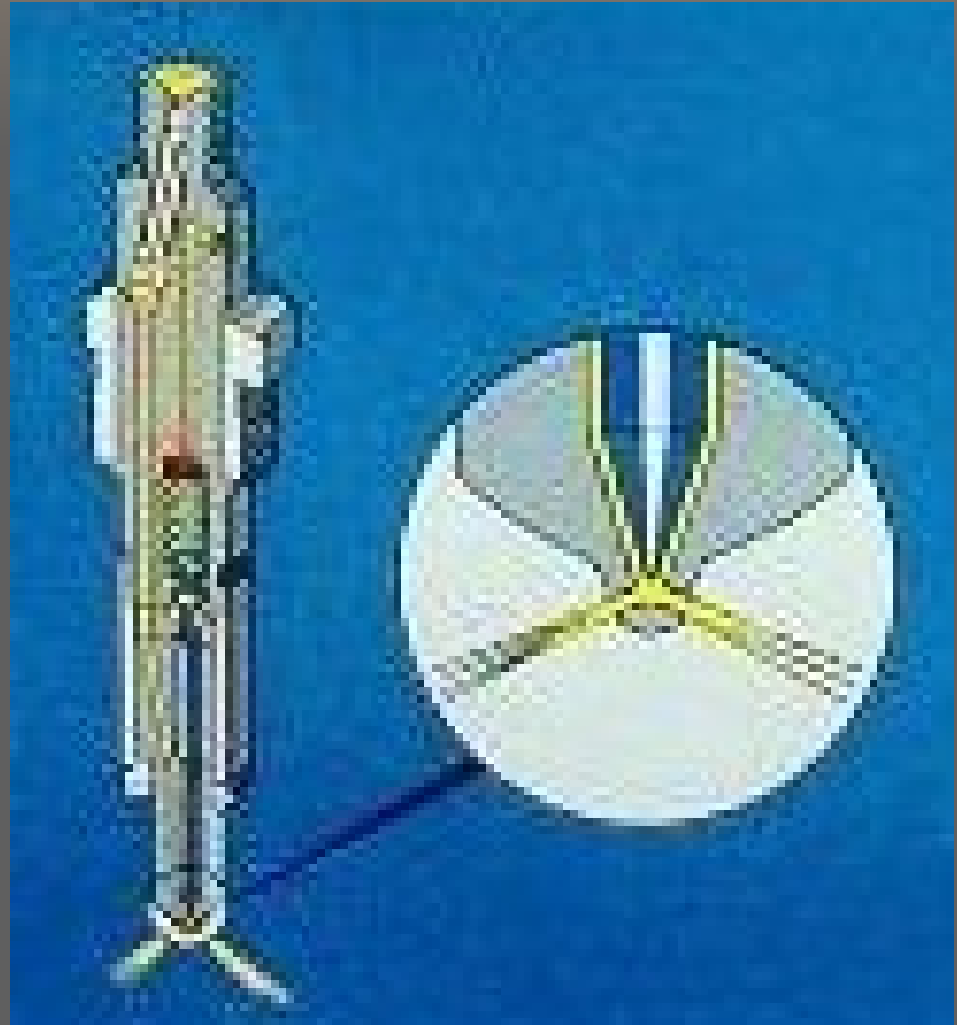
Hole type fuel injector

- The point at which the needle valve lifts is called the operating pressure setting.
- This is often referred to as the “pop” pressure setting.
- Shims are used to adjust the pop pressure setting.

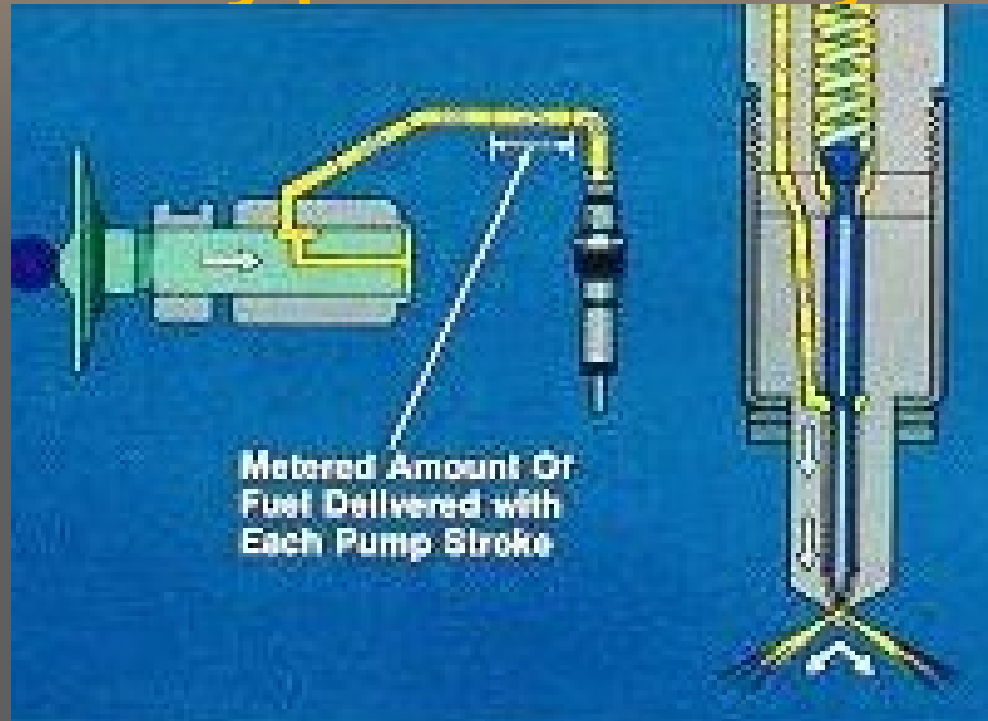


Hole type fuel injector

- ➔ During injection, the fuel pressure from the pump rises very rapidly to injection pressure.
- ➔ Fuel is forced through the spray holes in the nozzle tip, atomizing and distributing the fuel within the engine cylinder.

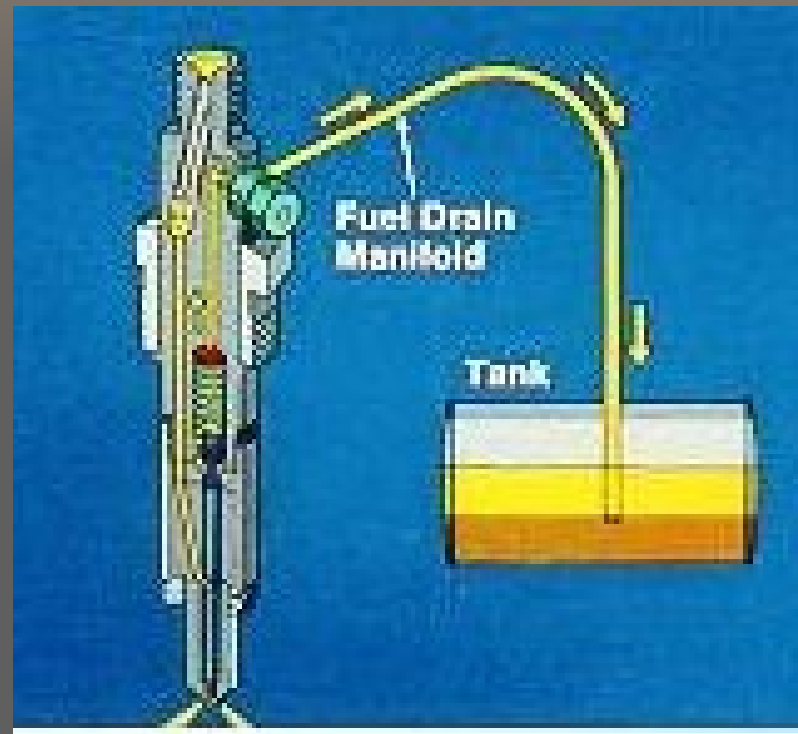


Hole type fuel injector



- The distributor pump delivers a metered amount of fuel per injection cycle.
- After injection, pressure in the nozzle is rapidly reduced.
- This permits the spring to force the needle valve down quickly.
- This action stops the flow of fuel into the cylinder and prevents exhaust gases from entering the needle.

Hole type fuel injector



- ➡ Fuel provides lubrication and some cooling effect for the needle valve.
- ➡ Fuel leaking past the needle valve drains through the spring cavity into the fuel drain manifold, and back to the supply tank.

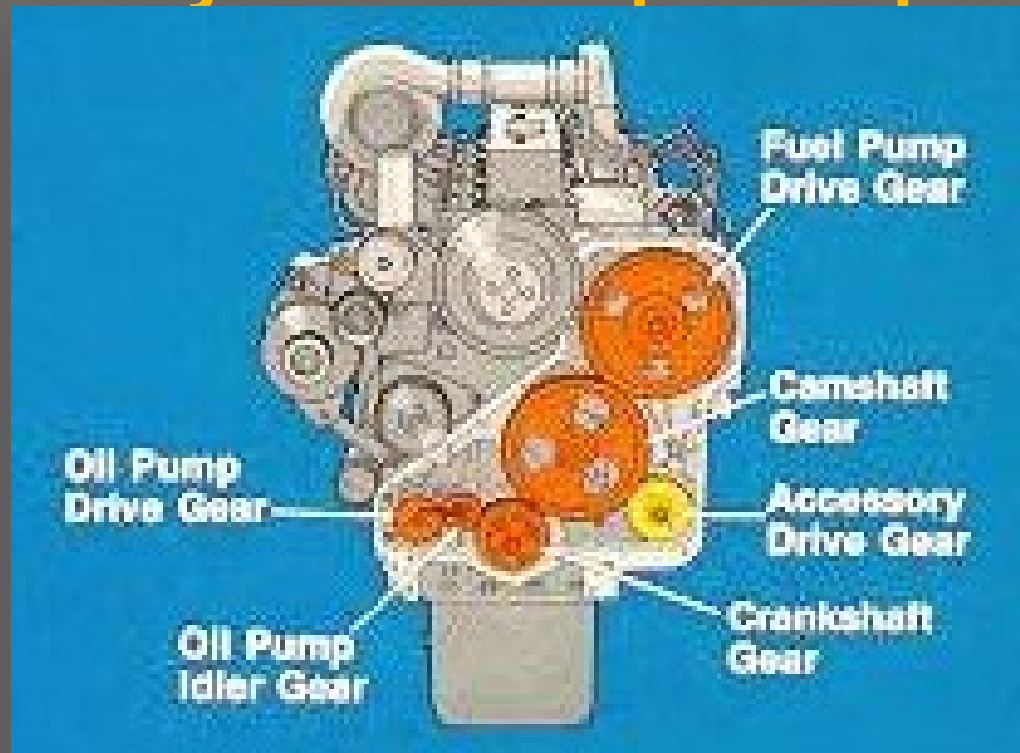


Any Questions ?



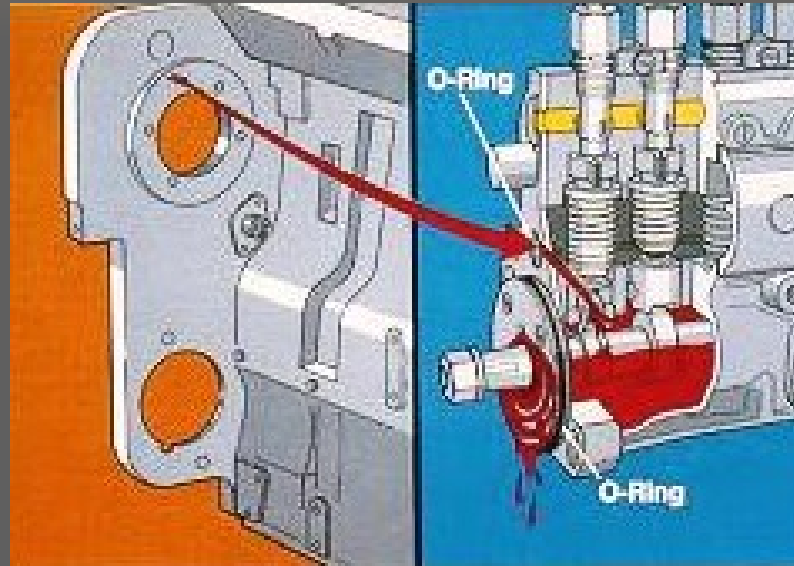
Take a 10 minute break

Robert Bosch Inline Injection pump



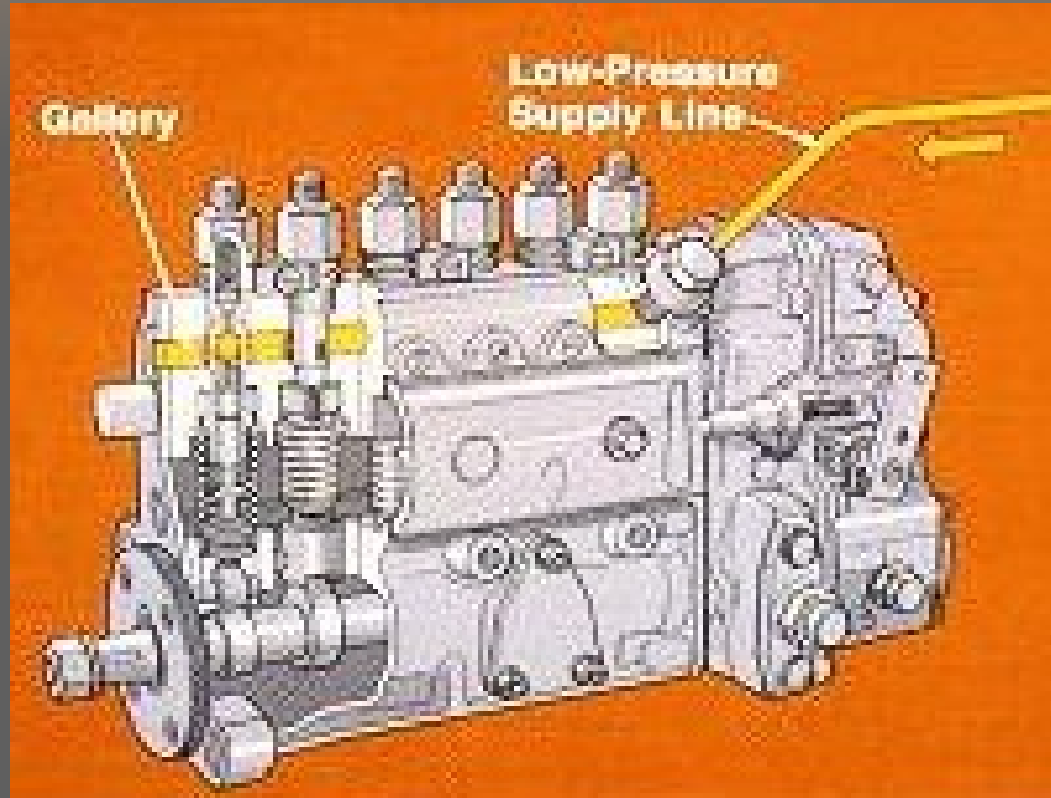
- ➔ The pump is driven at half engine speed by the camshaft gear.

Robert Bosch inline injection pump



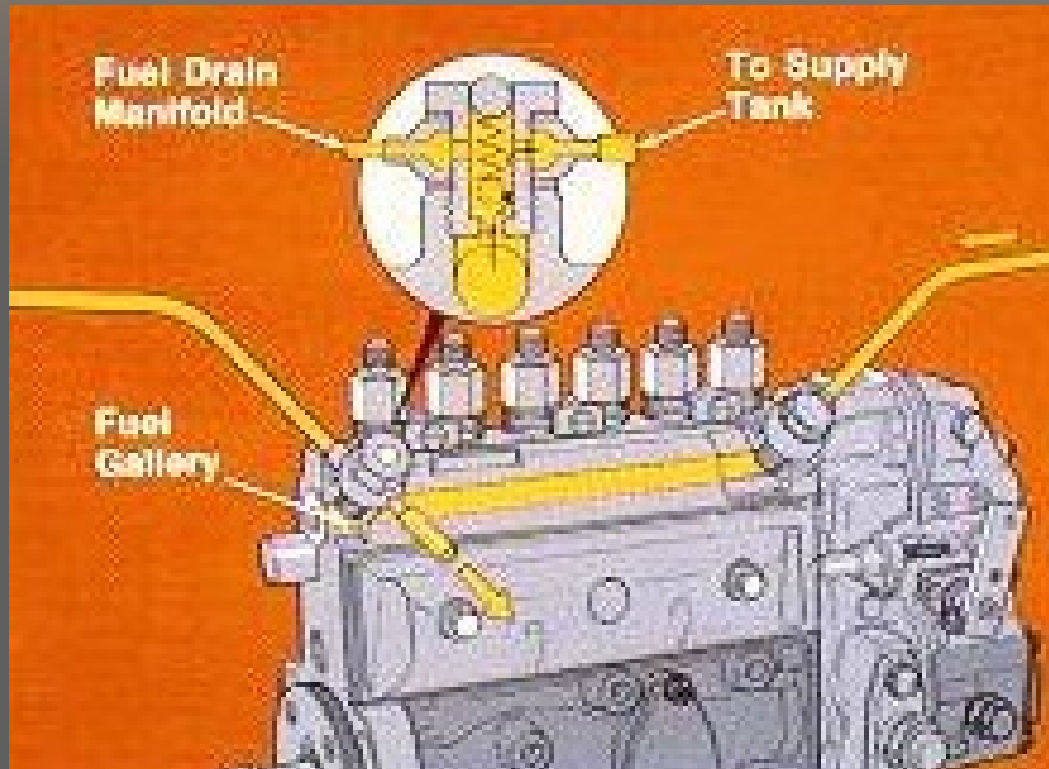
- Lubricating oil flow through a small orifice in the gear housing provides lubrication for the pump camshaft, roller-tappets and governor components.
- Oil returns to the gear housing through a drain hole above the pump shaft.

Bosch inline injection pump



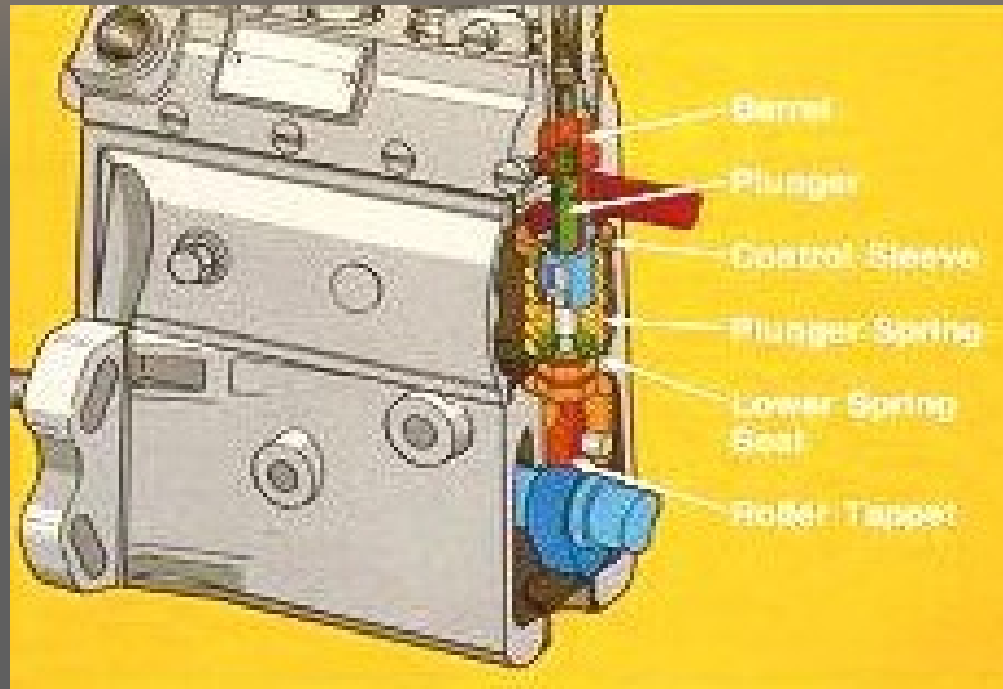
- ➔ Fuel flow through the injection pump is limited to the fuel galley.

Bosch inline injection pump



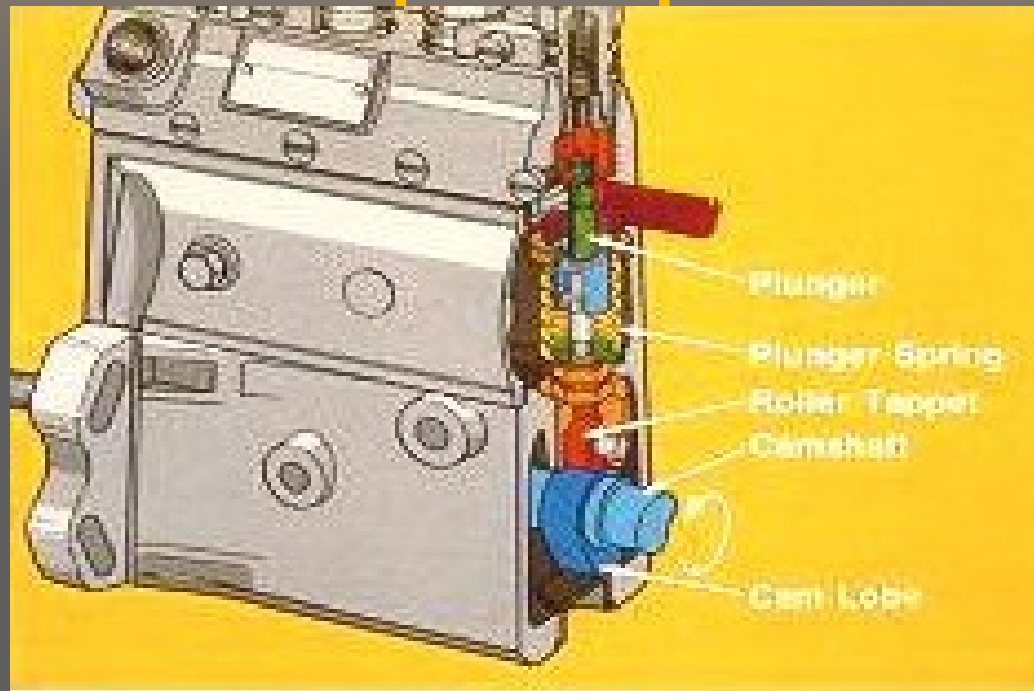
- ➡ The vent fitting contains a check valve that opens at 20 PSI to limit pressure in the gallery during engine operation.

Bosch inline injection pump



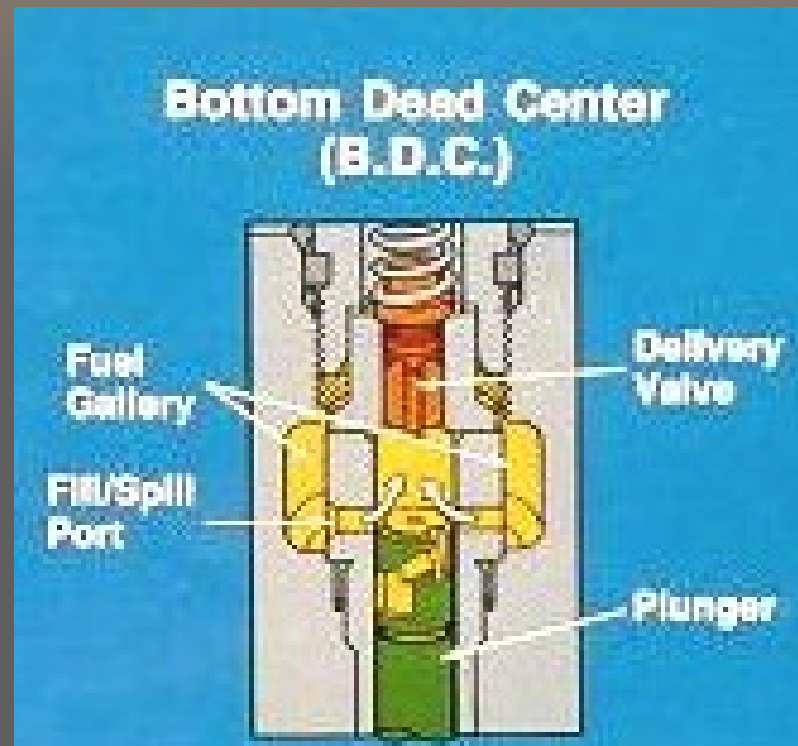
- Each pumping element consist of: The barrel, plunger, control sleeve, plunger spring, lower spring seat, and roller tappet.
- There is a pumping element for each engine cylinder. Lifting and retraction of the plunger provides the pumping action for fuel delivery.

Bosch inline injection pump



- ➔ As the camshaft rotates, the cam lobe lifts the plunger.
- ➔ The spring keeps the roller tappet in contact with the cam lobe, and causes the plunger to retract as the high point of the cam lobe rotates away from it.

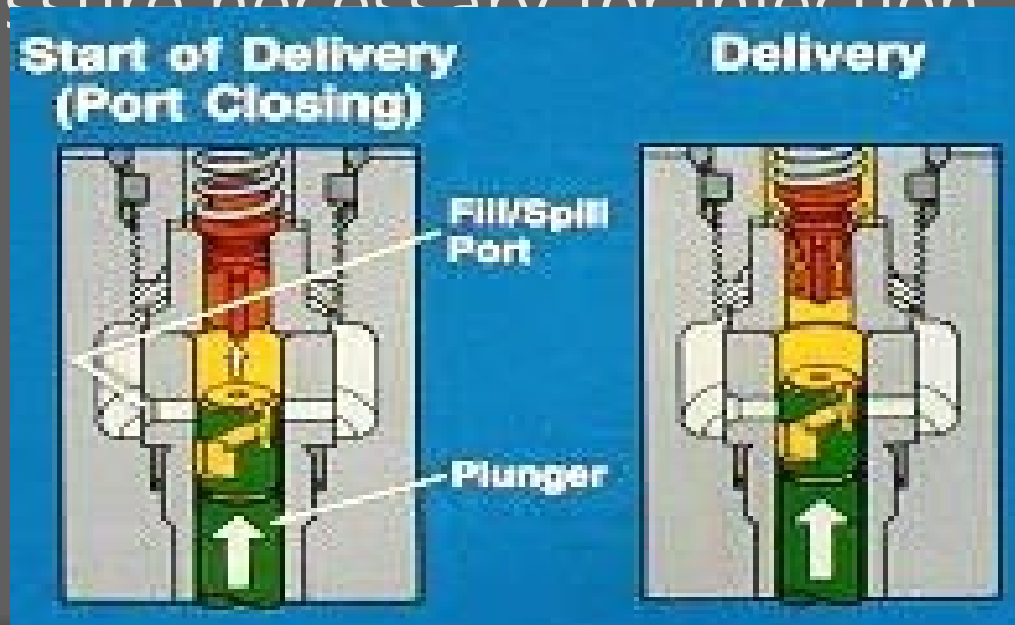
Pumping action to move fuel



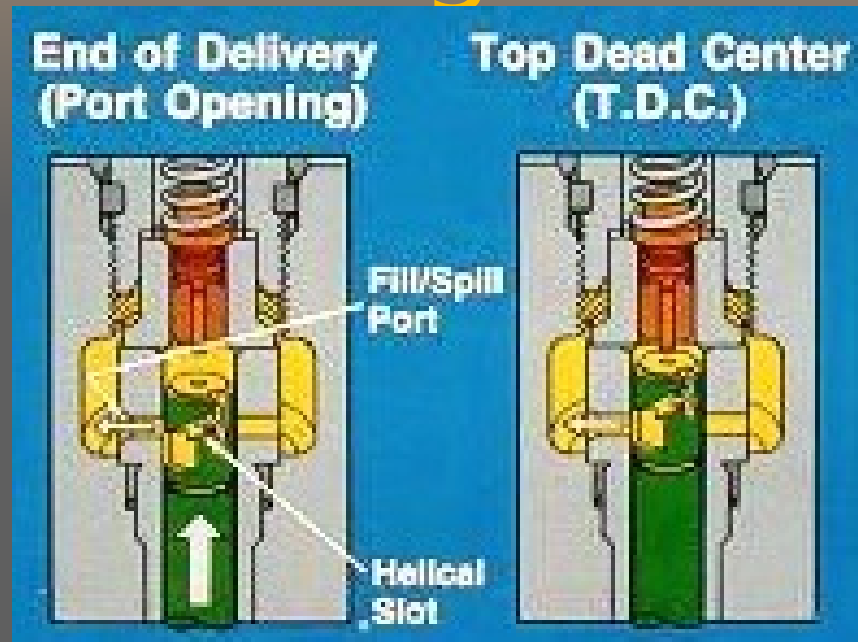
- ➔ The following sequence illustrates the pumping action for moving fuel from the gallery to the engine cylinder.
- ➔ At bottom dead center, fuel from the gallery fills the bore between the plunger and delivery valve.

Moving fuel

- As the plunger is lifted, the fill/spill port closes, sealing a quantity of fuel in the bore.
- Continued lifting of the plunger reduces the volume above the plunger, thus creating the fuel pressure necessary for injection.

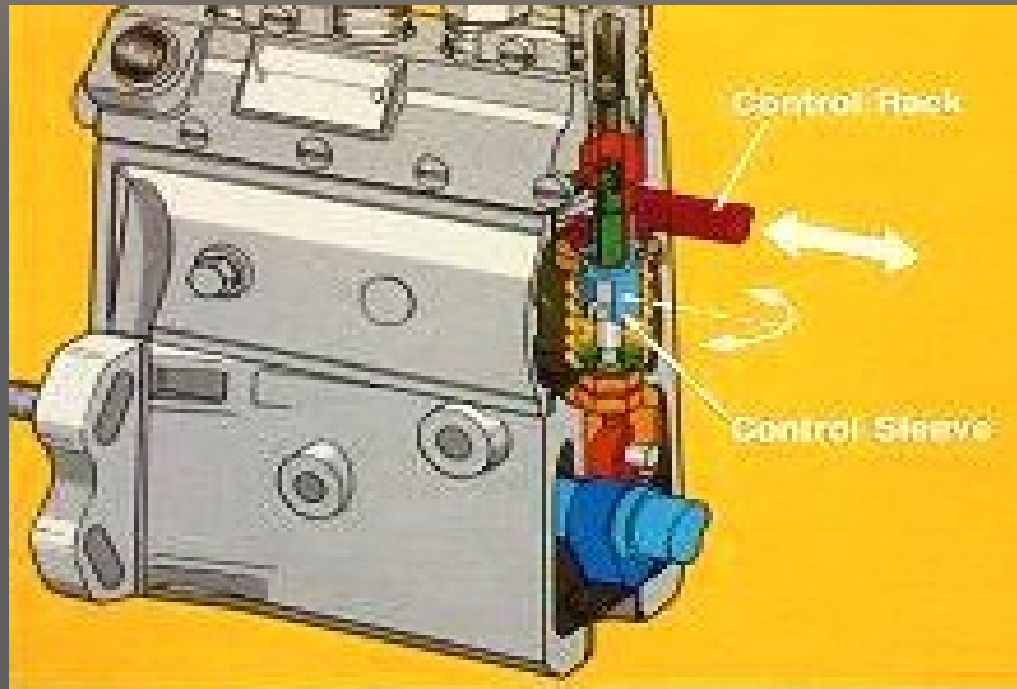


Moving fuel



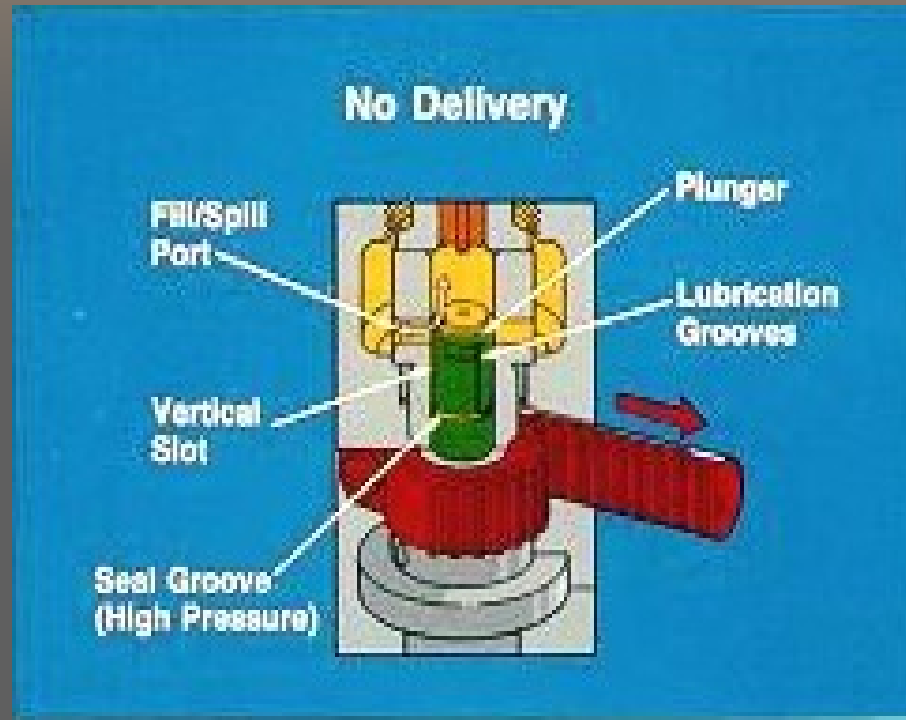
- Fuel injection stops when the helical slot on the plunger opens the fill/spill port.
- This action allows the fuel above the plunger to flow back to the fuel gallery.
- The plunger is lifted to top dead center, then once again retracted to bottom dead center to begin another cycle.

Amount of fuel injected



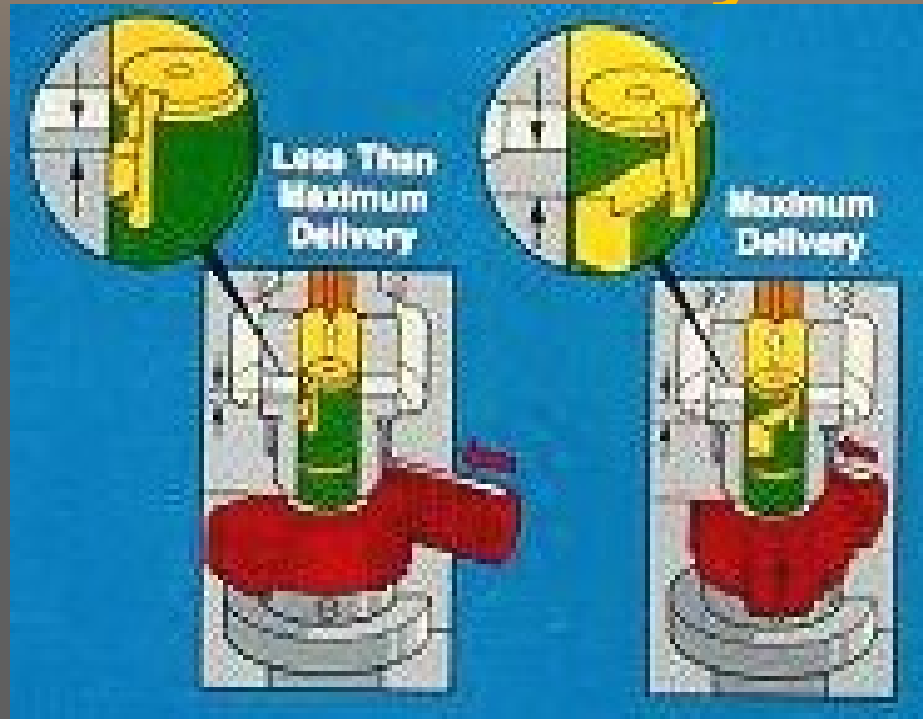
- ➡ The control sleeve rotates the plunger.
- ➡ This action controls the quantity of fuel delivered to the cylinder.

Zero Delivery of fuel



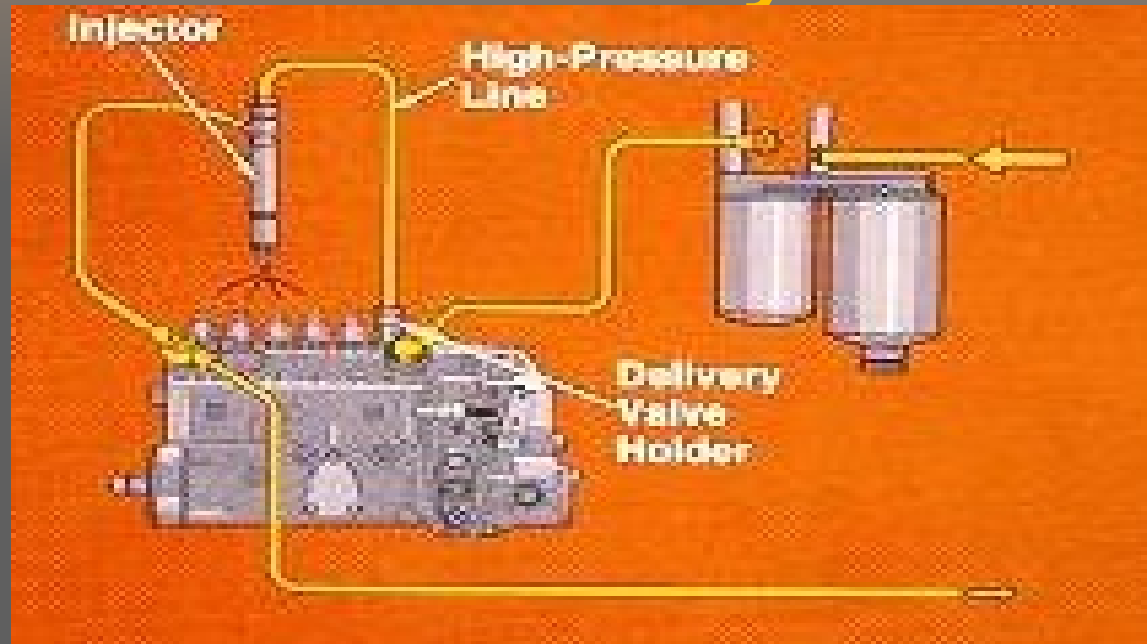
- For zero delivery, the plunger is rotated so the vertical slot on the plunger is aligned with the fill/spill port.
- In this position, fuel is not sealed above the plunger.

Less than max fuel delivery



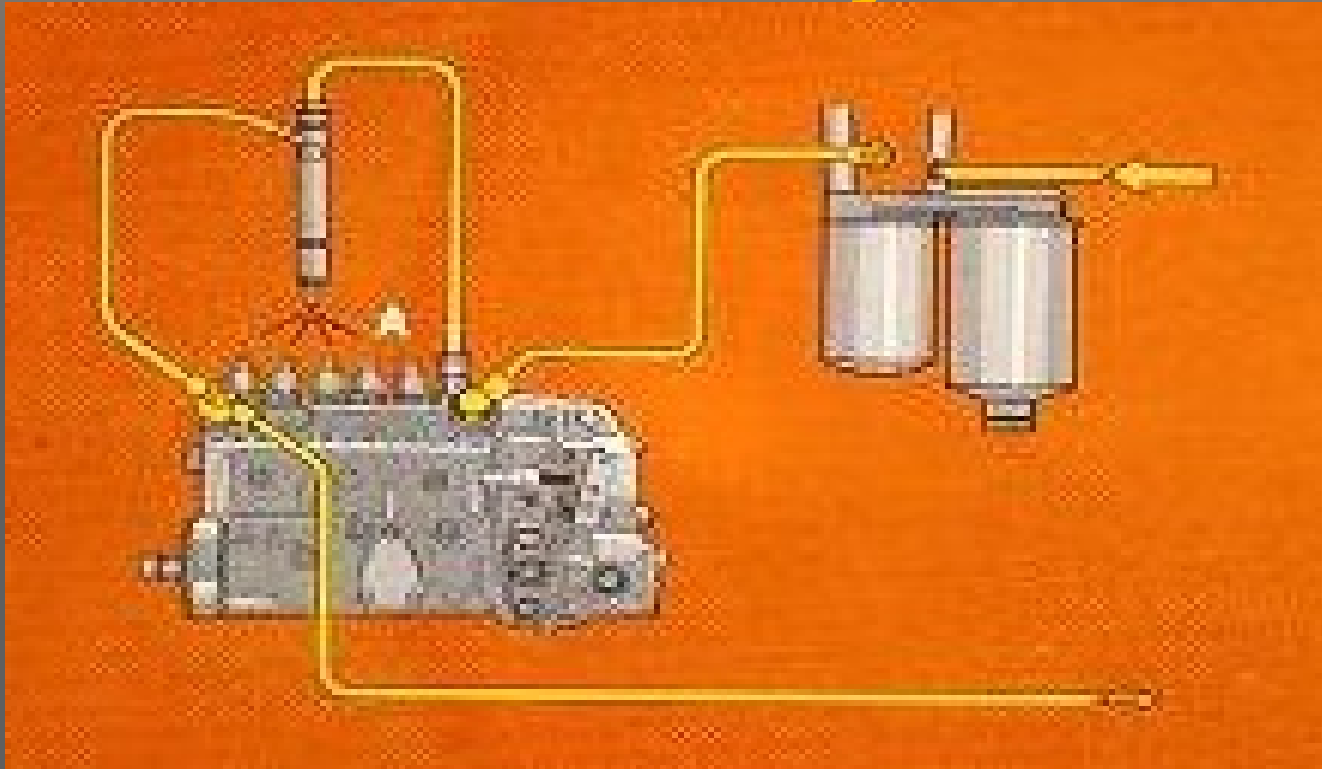
- ➔ For delivery of a quantity of fuel less than maximum, the plunger is positioned so the fuel is sealed above the plunger for some lift distance between port closure and port opening.
- ➔ For maximum delivery, the plunger is positioned so fuel is sealed above the plunger for the maximum lift distance between port closure and port opening.

Fuel flow that affects delivery



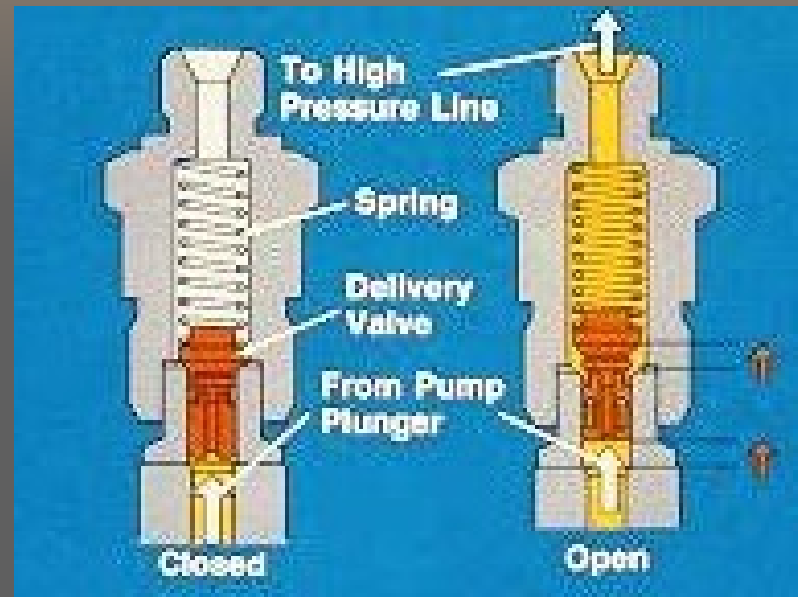
- ➡ During normal engine operation, the injectors, high-pressure fuel lines, delivery valve holders and plunger bores are completely filled with fuel.
- ➡ The delivery valve prevent drain back between injection cycles.

Fuel flow that affects delivery



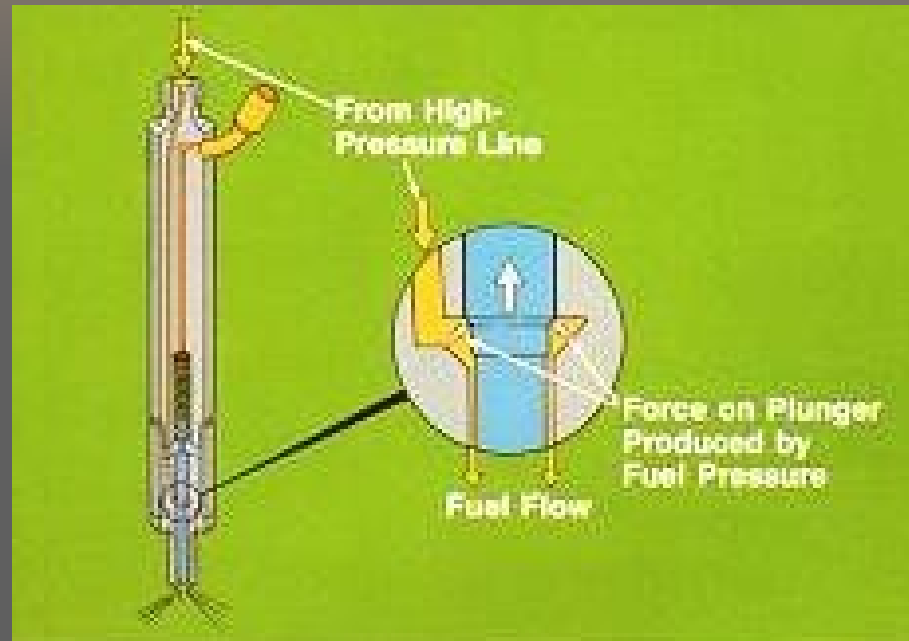
- ➔ Complete filling is important because the volume pumped (A) during each stroke displaces an equal amount from the injection nozzle.

Delivery cycle



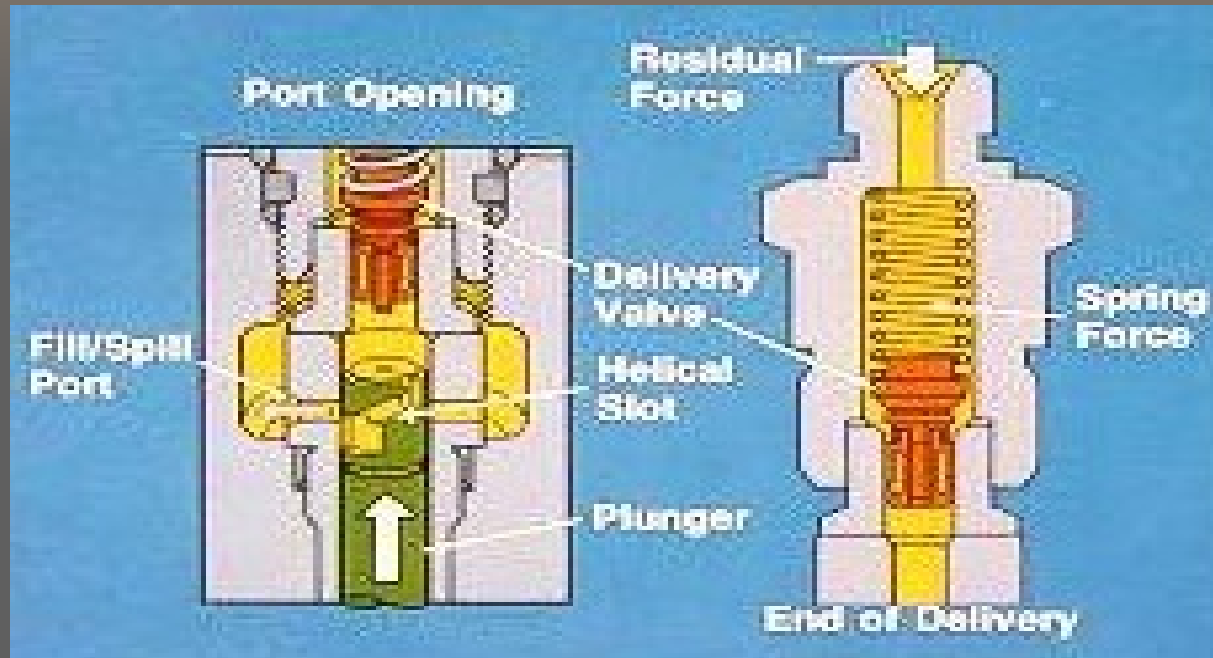
- ➔ Starting in the delivery cycle at the point where the plunger is lifting, causing pressure in the bore between the plunger and the delivery valve to rise.
- ➔ When this force exceeds the opposing forces of the spring and the residual pressure in the high-pressure line, the delivery valve opens.

Fuel in high pressure line



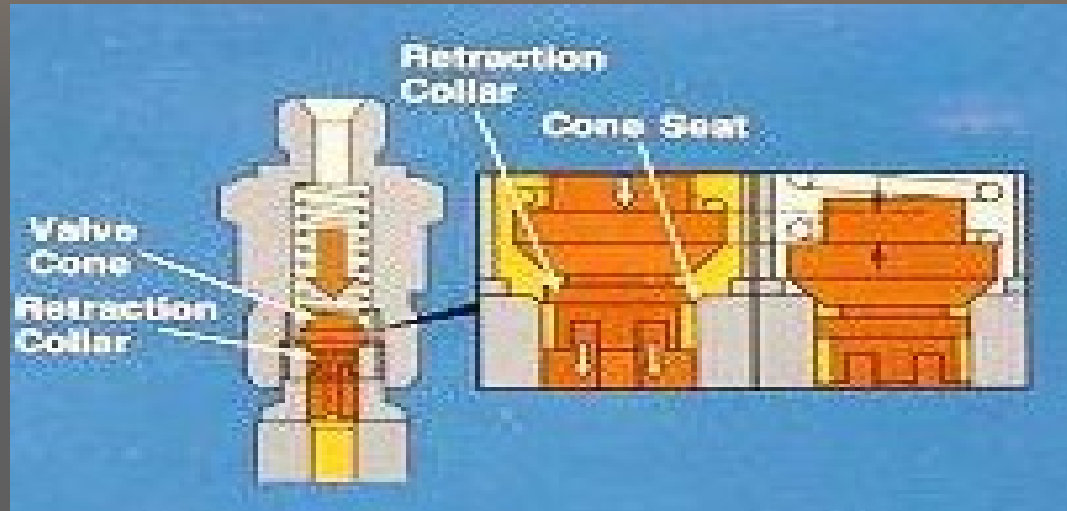
- Fuel displacement into the high-pressure line raises the pressure in the line until it overcomes the spring force on the needle valve in the injector, causing it to open.
- The fuel pressure continues to rise as fuel is forced through the spray holes in the nozzle tip.

Fuel pressure on the plunger



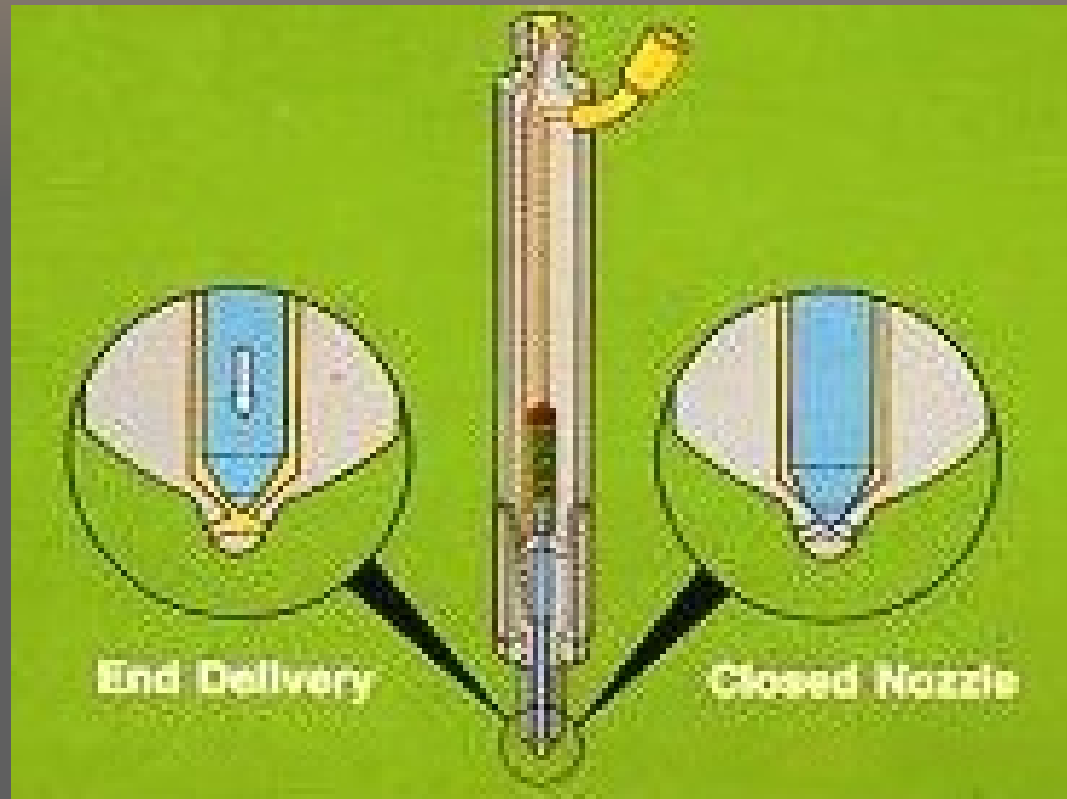
- When the helical slot on the plunger passes the port to the fuel gallery, pressurized fuel above the plunger escapes.
- At this time, the pressure and force on the delivery valve are reduced, allowing the delivery valve to close.

Delivery valve



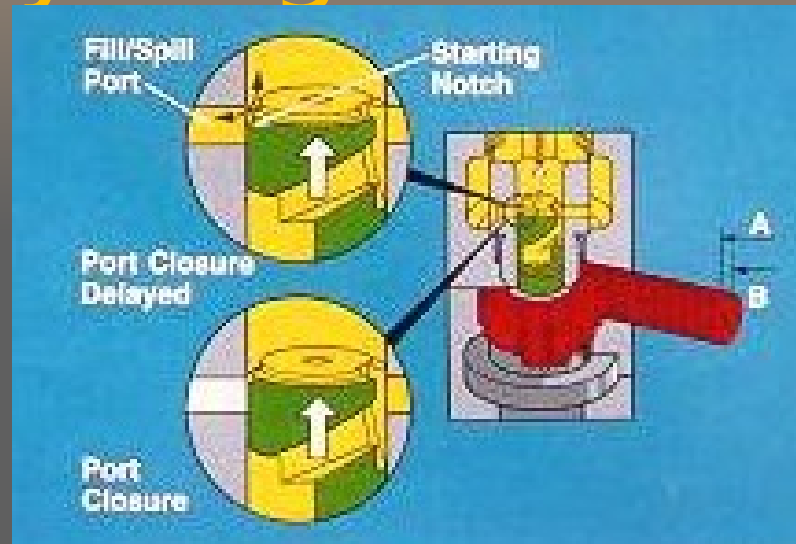
- ➔ The delivery valve performs two functions as it closes:
- The retraction collar seals the fuel in the high-pressure line as it enters the valve body
 - Then, continued movement of the valve cone to its seat on the valve body increases the volume available for fuel, allowing the pressure in the high-pressure line to be reduced rapidly.

Needle valve in the injector



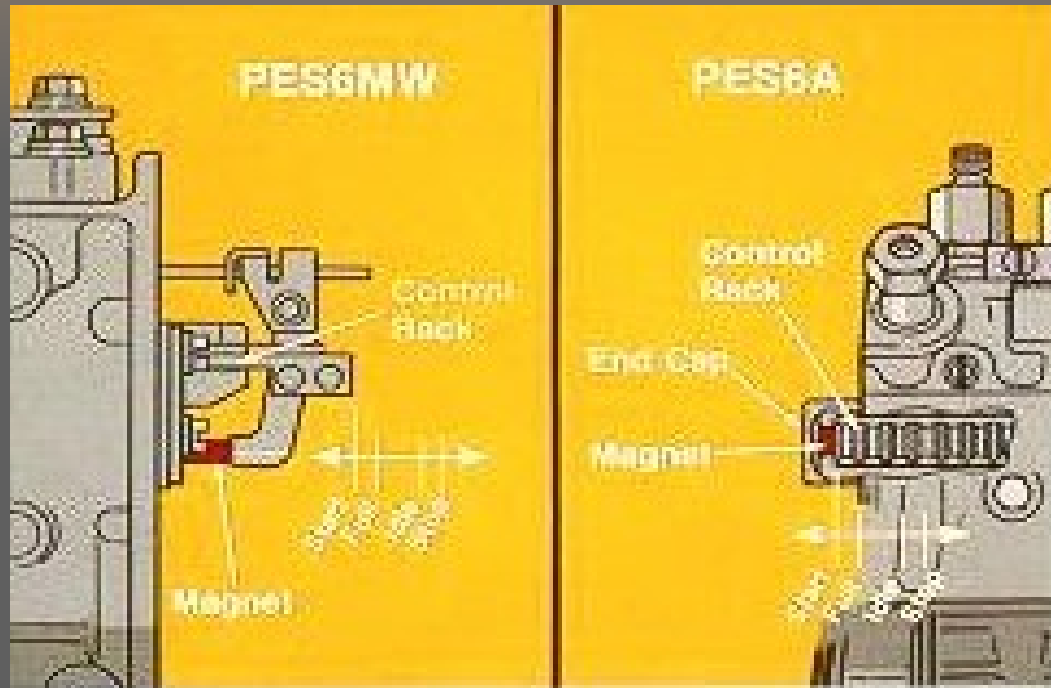
- Reduction of pressure in the high-pressure line allows the needle valve in the injector to close very quickly.
- This action prevents dribbling of fuel into the engine cylinder.

Easy engine starting



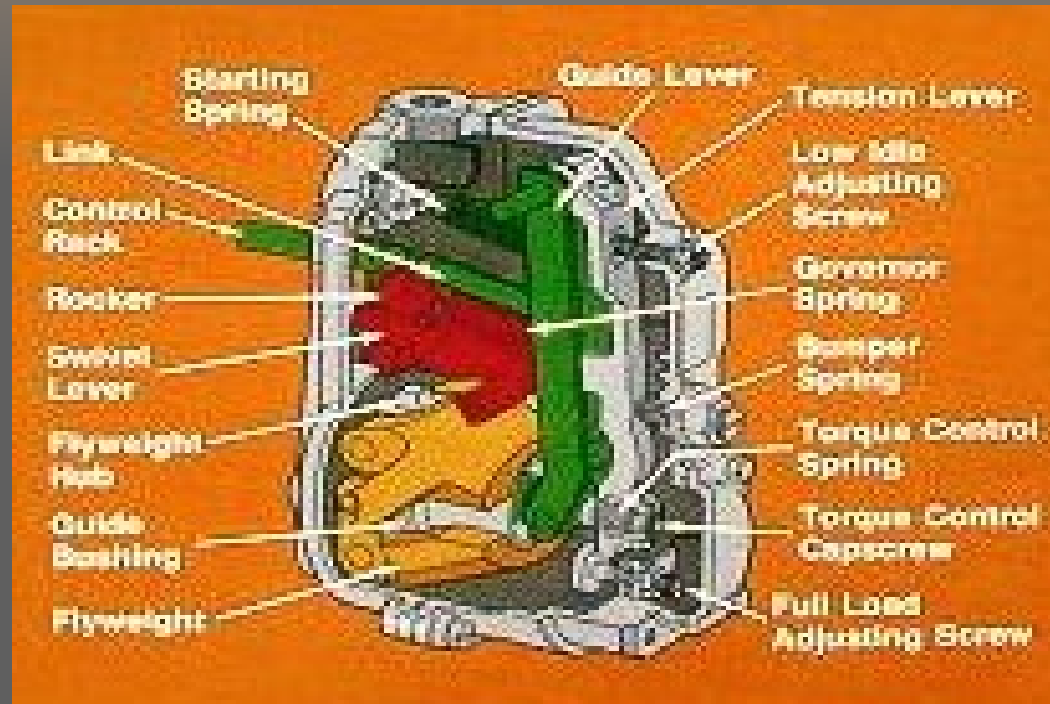
- The starting notch on the pump plunger provides retarded timing for easier engine starting.
- When the rack is in the start position(A) Extended beyond the maximum operating position(b), the starting notch aligns with the fill port for filling.
- When the plunger is lifted at this position, maximum fuel will be delivered, but a little later, because port closure is delayed until the edge of the notch closes the fill port.

RSV Governor



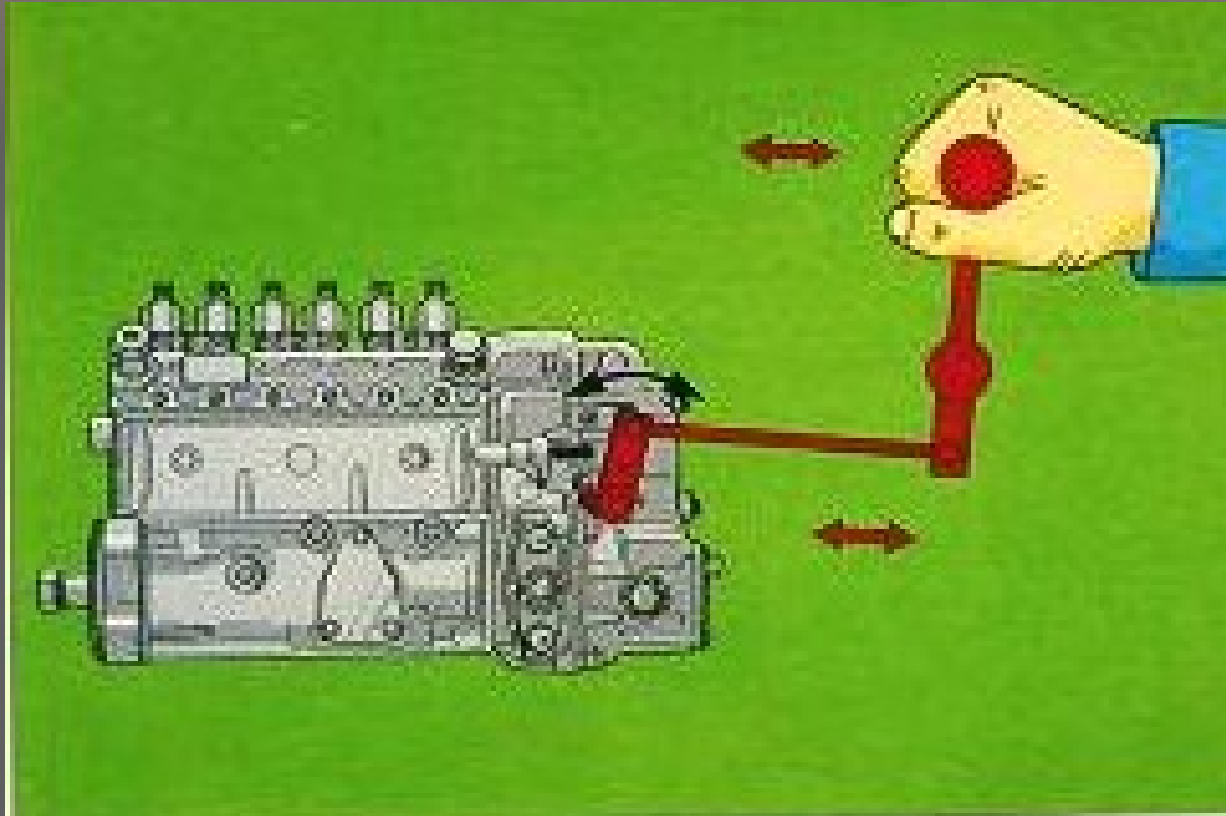
- ➔ On engines equipped with the RSV governor, a magnet holds the control rack in the starting position until the flyweight force of the governor is strong enough to pull the rack toward the idle position.

RSV Governor



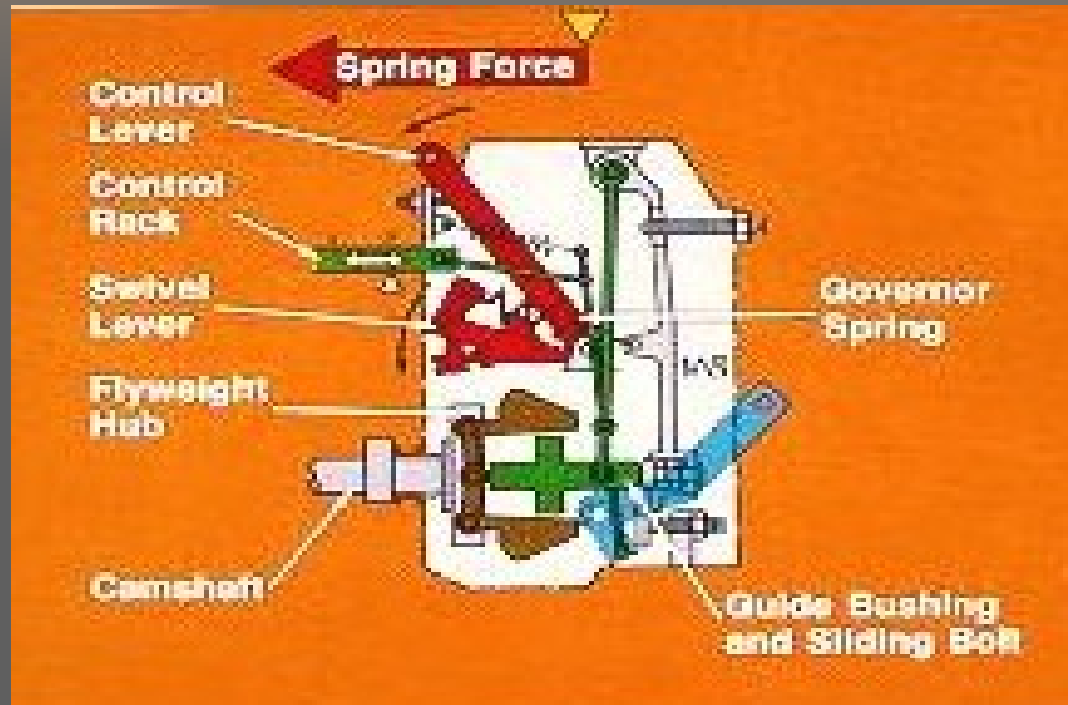
- The RSV is a mechanically governed, variable-speed governor.
- The flyweights are driven by the injection pump camshaft.
- Springs and linkage connect the control lever to the pump control rack, which controls the quantity of fuel delivered by the pumping elements.

RSV governor operation



- ➡ The operator determines the desired speed between idle and governor break by moving the engine speed control.

RSV governor operation



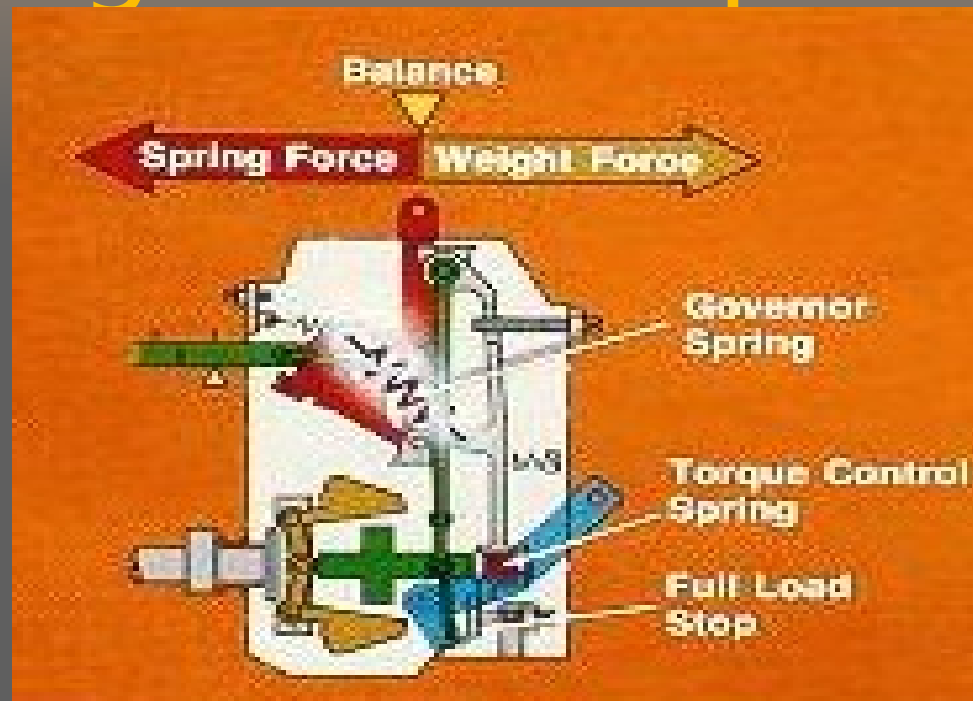
- Moving the control lever, initially re-positions the pump control rack and establishes a spring force to oppose the centrifugal force of the flyweights.
- The control lever has been positioned for full speed.

RSV governor operation



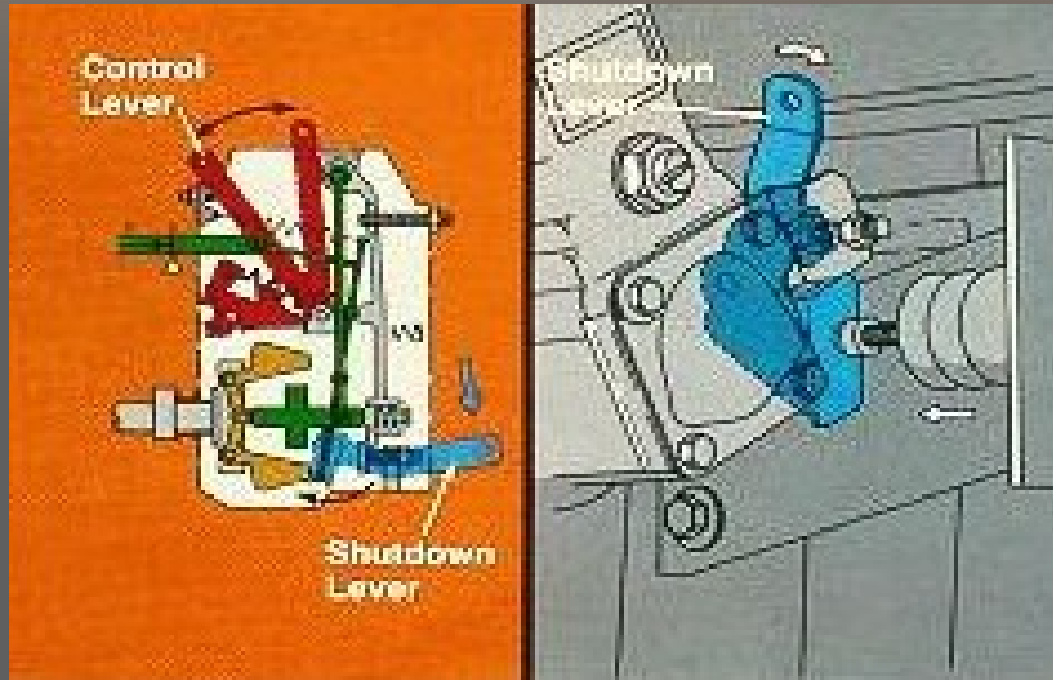
- ➔ The control lever is now in the half-speed position.
- ➔ When the engine reaches the speed corresponding to the lever position, the opposing forces are in balance.
- ➔ The control rack is now positioned to maintain a constant speed until engine loading or speed control position is changed.

RSV governor operation



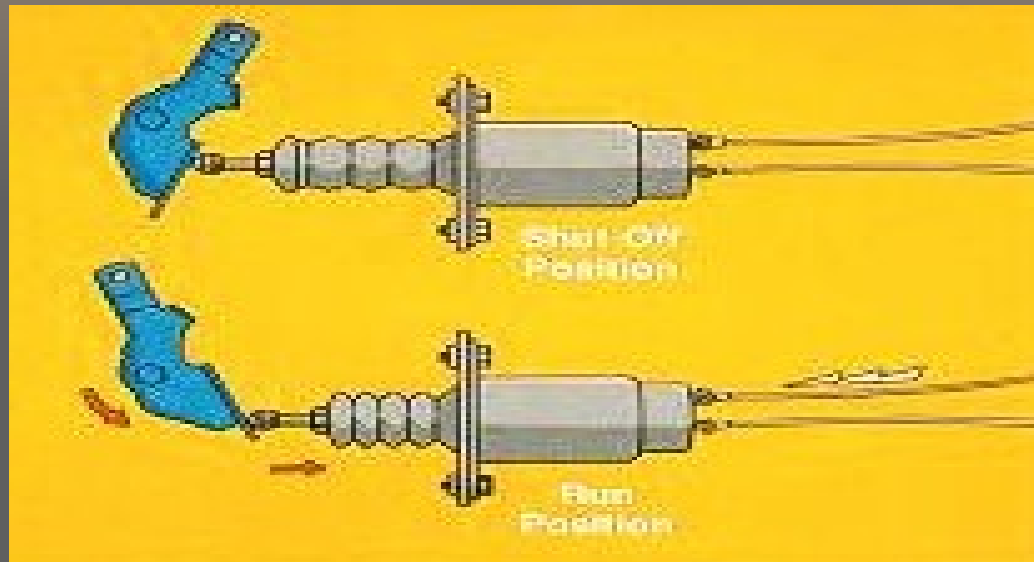
- The spring in the torque capsule also opposes the flyweight force.
- The force of the spring is adjusted during test to provide the desired fuel delivery during mid-range operation.
- The full load stop limits the fuel delivery under load.

RSV governor operation



- ➔ A second control lever is used for engine shutdown.
- ➔ When you move the lever in the direction shown, the control rack is pulled to the stop position. At this time no fuel is delivered to the engine, regardless of the engine speed control position.

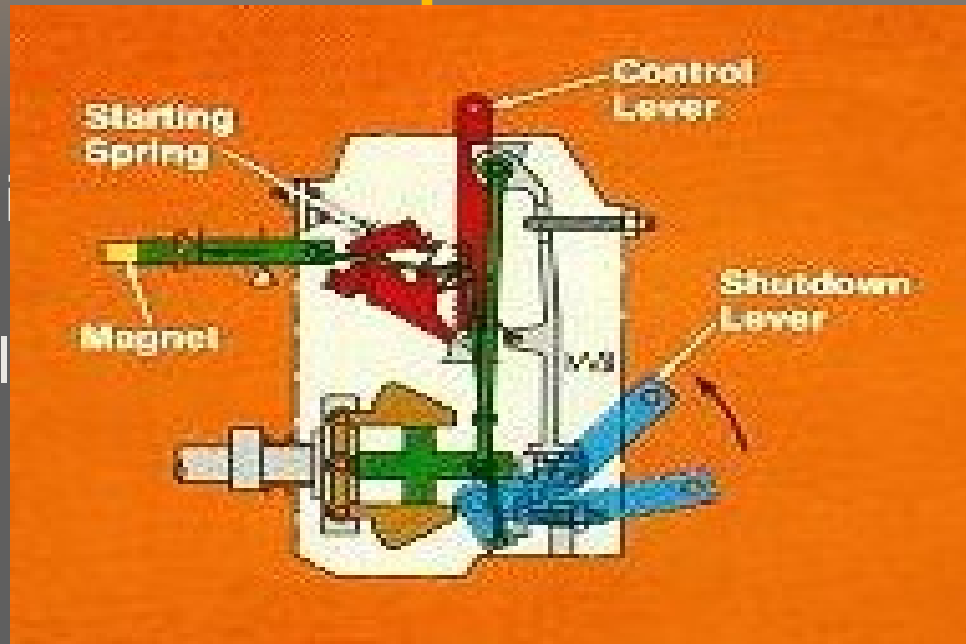
RSV governor operation



- ➔ A solenoid control starting and stopping.
- ➔ The solenoid plunger is spring loaded in the starting position.
- ➔ The solenoid is mounted on the engine so the extended plunger will hold the shutdown lever in the shutdown position until the solenoid is activated.
- ➔ When the solenoid is energized for starting the engine, the plunger retracts and the shutdown control lever is moved to the run position by a spring on the control lever shaft.

RSV governor operation

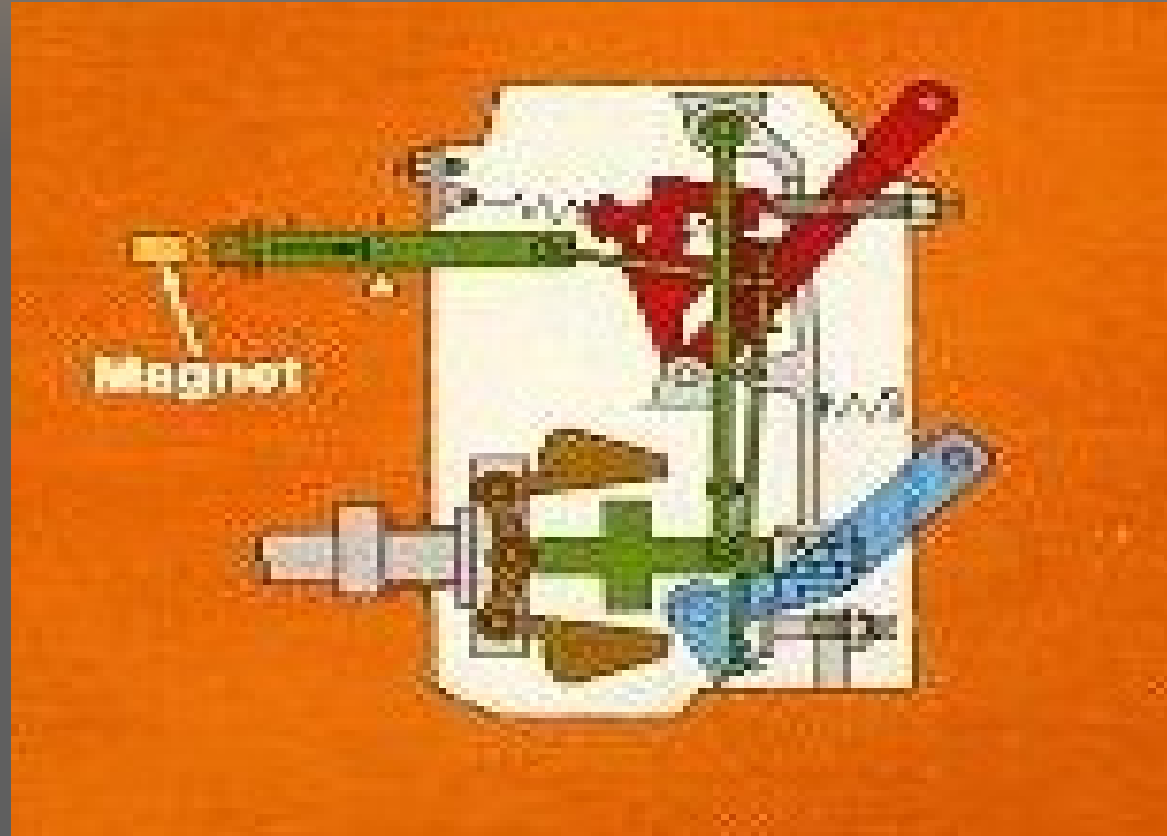
➔ With the flyweights
At rest, and the solenoid
activated, the starting
spring pulls the control
rack to the starting
position for maximum
fuel delivery.



The magnet on the pump holds the rack in that position until the engine starts and the speed is sufficient for the flyweight force to overcome the magnetic force.

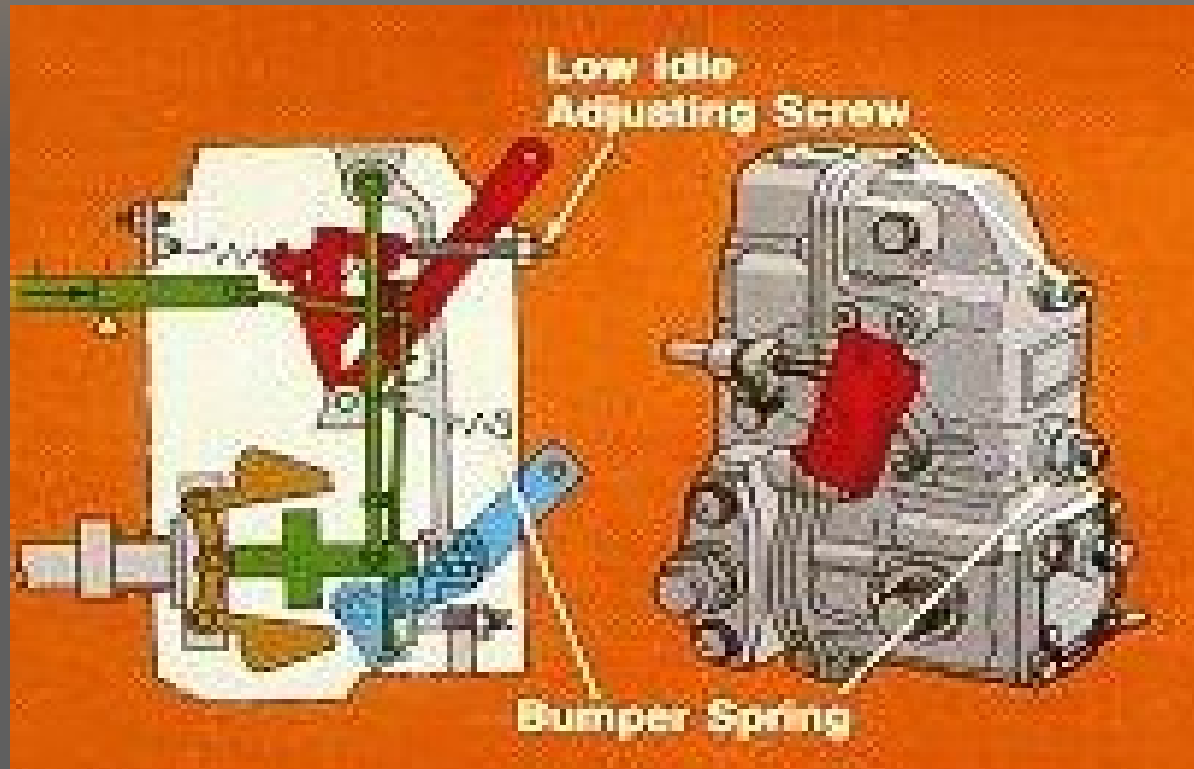
The control lever in this slide is positioned at half-speed; however, you do not have to move the engine speed control from idle to start the engine. You will need to put the shutdown lever in the run position.

RSV governor operation



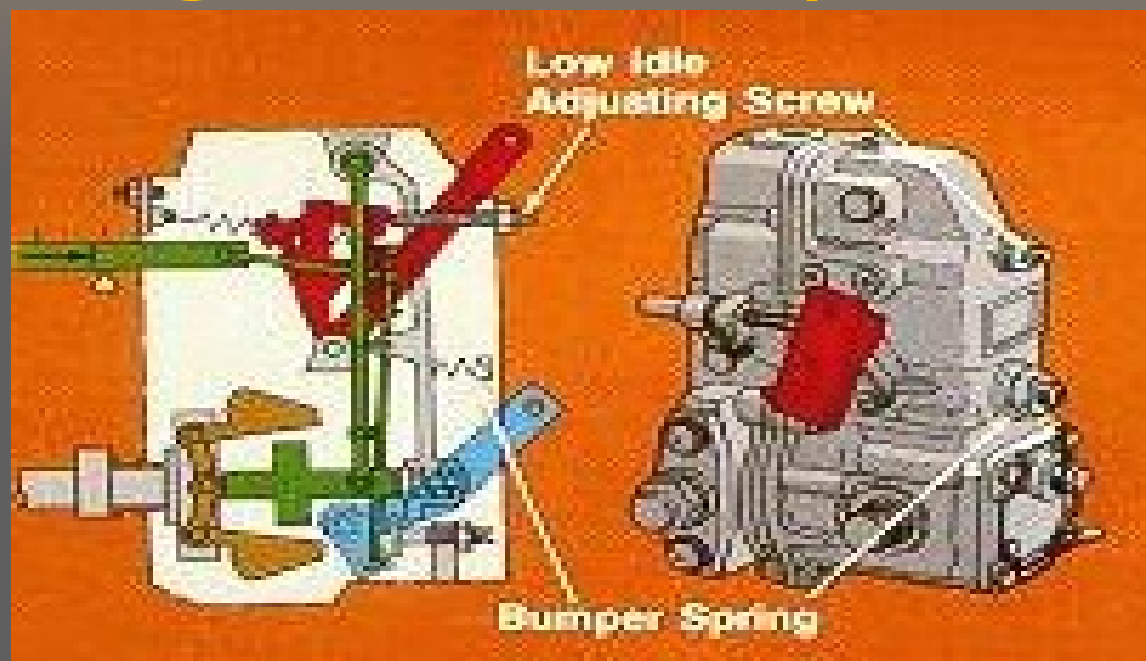
- ➡ The engine speed will drop back to the idle after the force is broken and the rack is moved to the idle position.

RSV governor operation



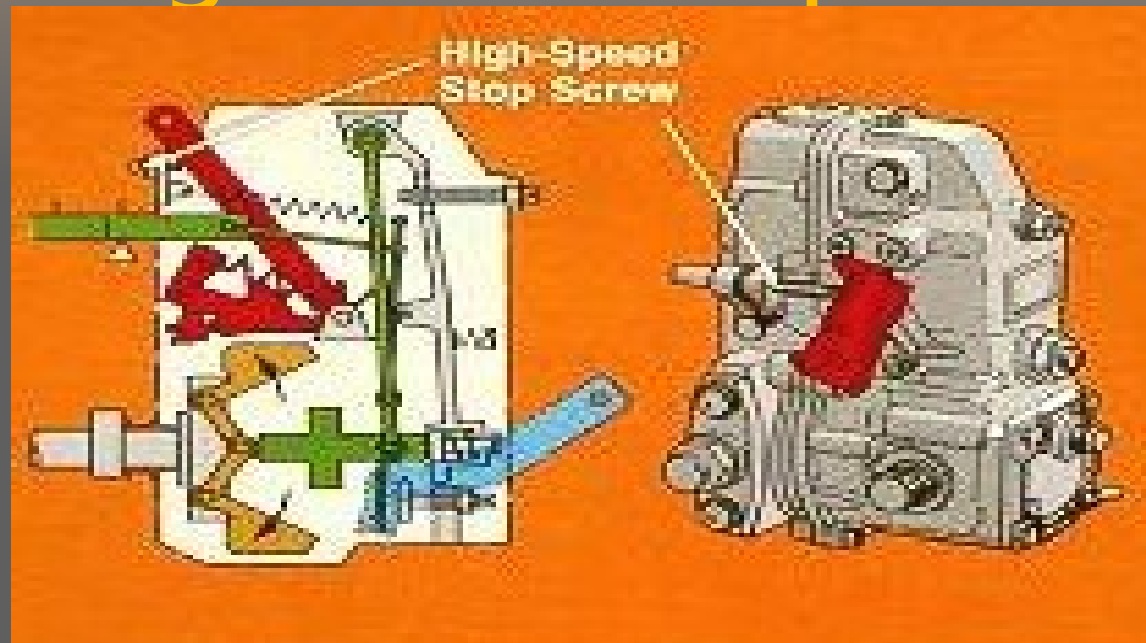
- When the engine starts, the flyweights will move outwards, exerting enough force to overcome the governor spring force.
- Idle speed will be stabilized when these forces are equal.

RSV governor operation



- The low idle and bumper spring adjusting screw allow you to adjust engine idle speed.
- The bumper spring provides a cushioning effect to stabilize idle speed when the engine speed control is quickly brought back to the idle position.
- Always refer to the service manual when adjusting idle.

RSV governor operation



- The high idle adjustment is set at the factory, it should not require adjustment.
- When the control lever is against the high-speed stop, the tension on the governor spring is at maximum. For this reason, the speed and centrifugal force of the flyweight will also need to be at maximum.
- The speed at which the forces are balanced is the high-idle speed.



Questions ?

Take a 10 minute break !

Caterpillar Scroll Fuel Injection System

- ➡ The Caterpillar Scroll Fuel Injection pump is a system consisting of:
 - Scroll injection pump
 - Governor
 - Fuel Ratio Control assembly

Differences

- ➡ There are minor differences between the Caterpillar system and the two previous systems we discussed.
- ➡ Although they perform the same functions, they are located in different sequences.



Components of the system and how they function

Fuel Tank

- ⇒ Reservoir for the fuel
- ⇒ Contains baffle plates which strengthen the sides and top

Primary Fuel Filter

- ⇒ Located between the fuel pump and the hand priming pump.
- Functions under suction
- Removes large particles from the fuel that could damage the transfer pump.

Hand Priming Pump

- ➡ Located between primary fuel filter and the fuel transfer pump.
- ➡ It is used to fill the system with fuel and remove air from the fuel filters and lines up to the fuel injection pump housing

Priming pump operation

- ➡ Unlock priming pump handle and pull upwards
 - This causes a negative pressure in the priming pump body.
 - When the handle is drawn upwards, the negative pressure it creates will open the left check valve in the body of the pump and draw fuel from the tank through the primary fuel filter into the priming pump body.

Priming pump operation

- ➔ Pushing down on the priming pump handle then closes the left check valve and opens the right check valve allowing fuel to be sent through the fuel transfer pump to the secondary filter and into the injection pumps fuel manifold.

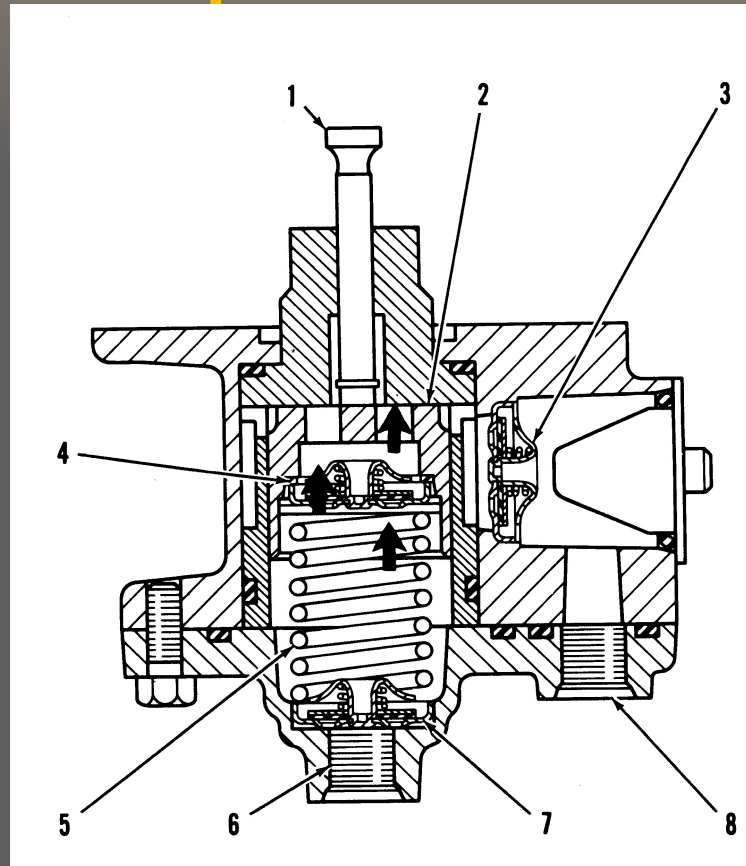
Priming pump operation

- ➡ Once the fuel reaches the fuel manifold, the constant bleed valve will open and allow excess fuel pressure and trapped air to return to the fuel tank by way of a fuel return line.

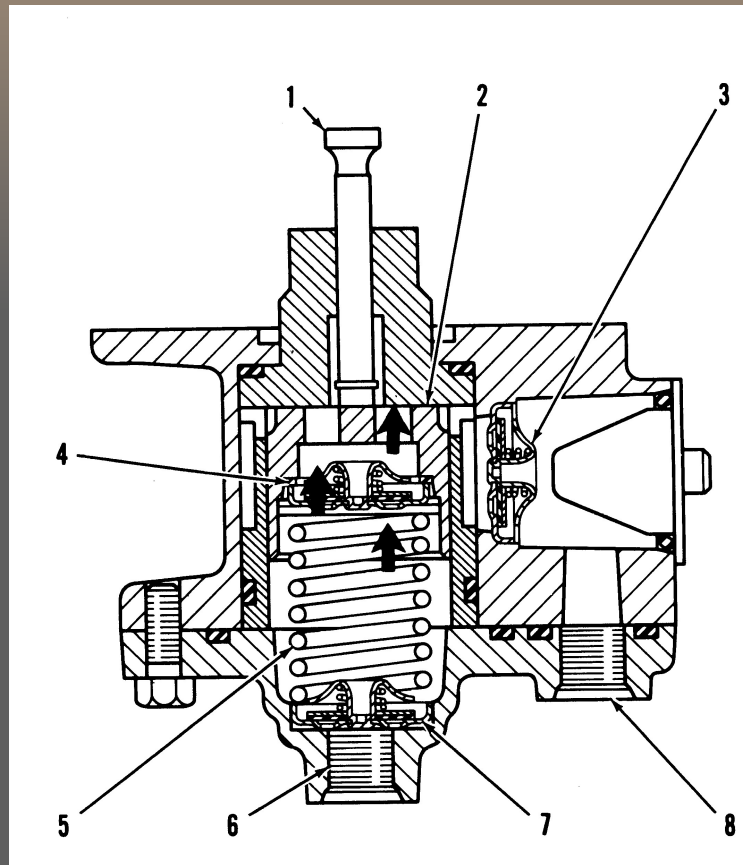
Fuel Transfer Pump

- ➡ It is a piston pump that is moved by an eccentric cam on the camshaft for the fuel injection pump
- ➡ The fuel transfer pump is located on the bottom side of the fuel injection pump housing

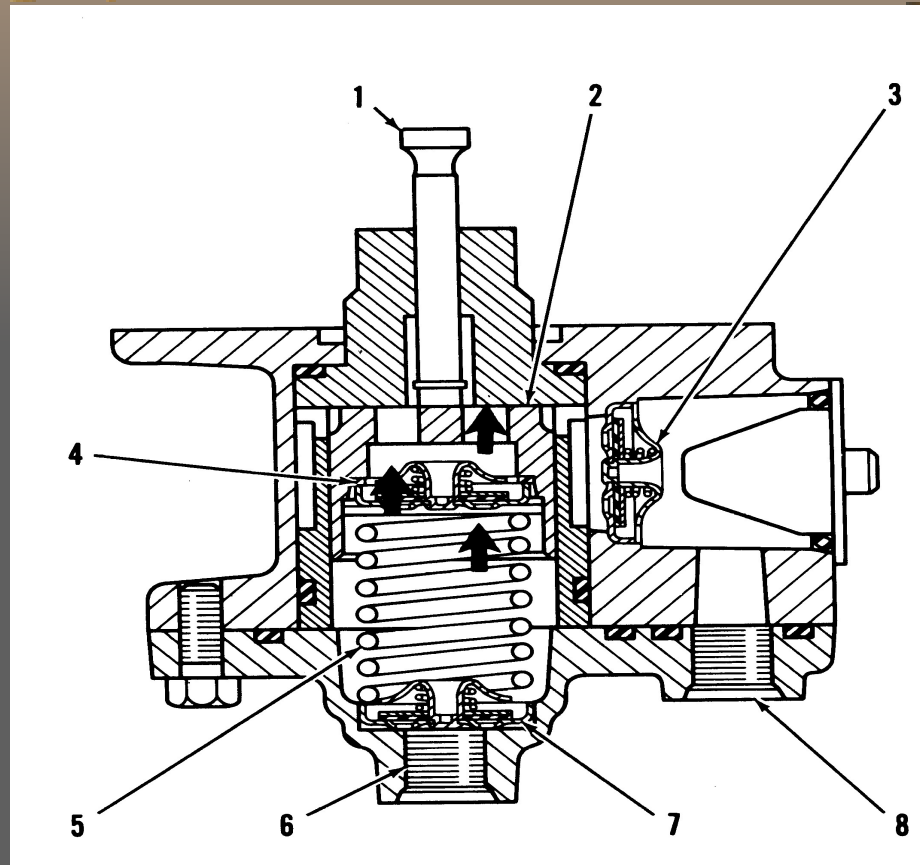
Fuel transfer pump operation



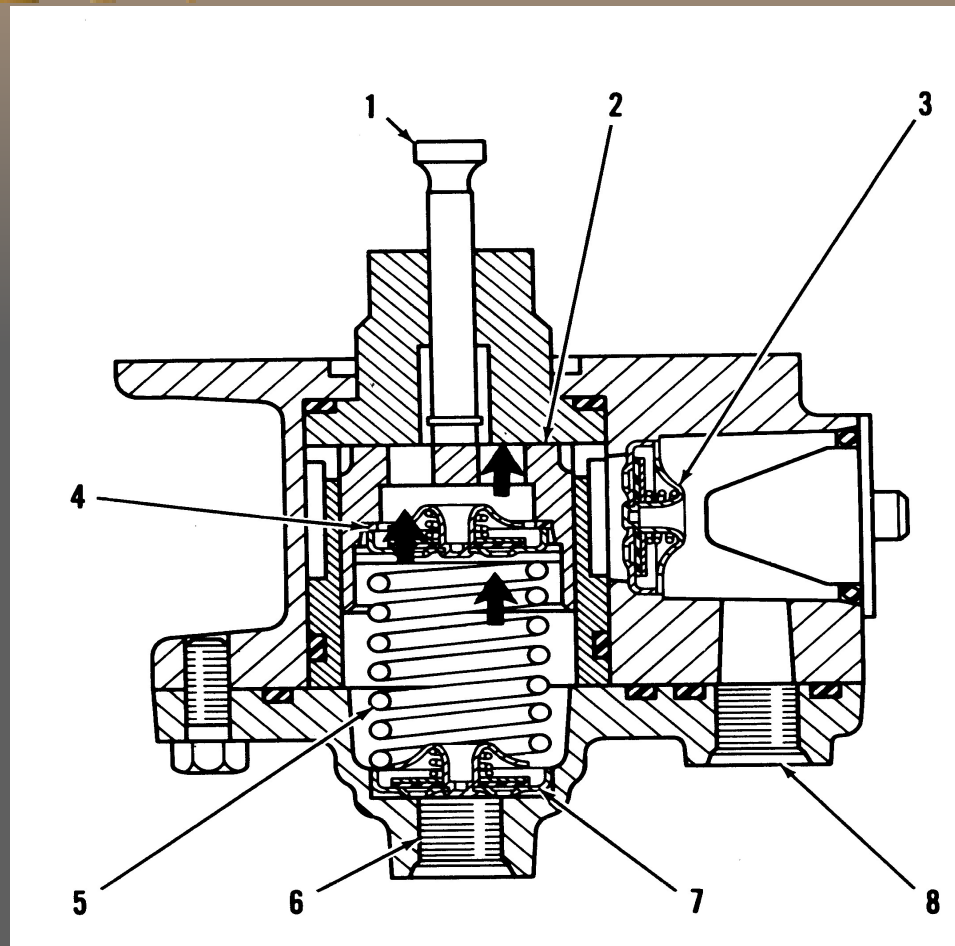
- ➔ When the fuel injection pump camshaft turns,, the cam moves pushrod (1) and piston (2) down. As the piston moves down, inlet check valve (7) and outlet check valve (3) closes.



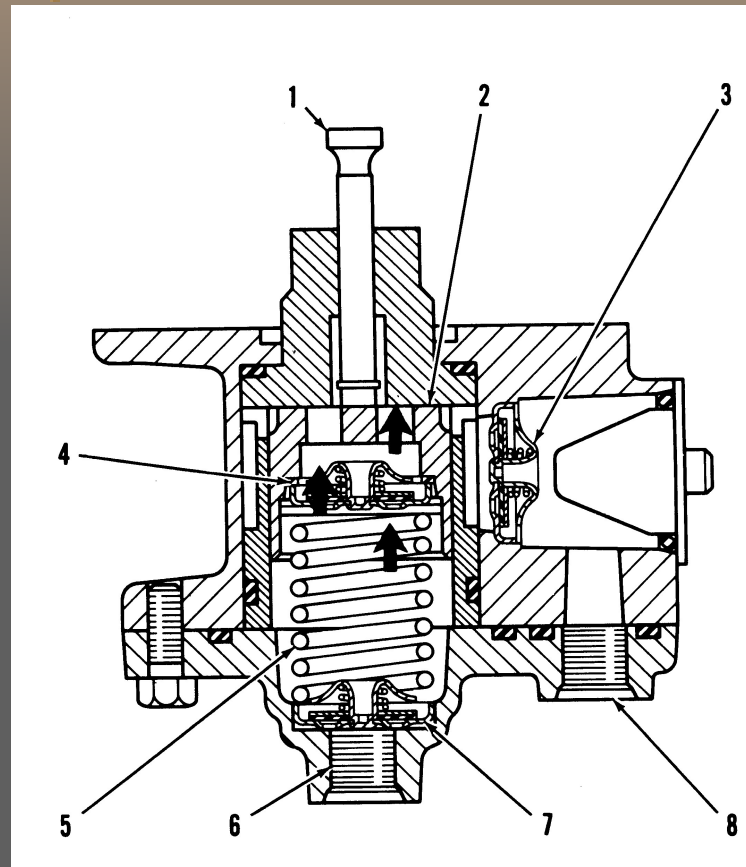
- ➡ Pumping check valve (4) opens and allows fuel below the piston to move to the area above the piston. Pumping spring (5) is compressed as the piston is pushed down by pushrod (1).



- As the fuel injection pump camshaft continues to turn, the cam no longer puts force on pushrod (1).
- Pumping spring (5) now moves piston (2) up.
- This causes pumping check valve (4) to close.



- ➔ Inlet check valve (7) and outlet check valve (3) will open.
- ➔ As the piston moves up the fuel in the area above the piston is pushed through the outlet check valve (3) and out pump outlet port (8).



- ➡ Fuel also moves through pump inlet port (6) and inlet check valve (7) to fill the area below piston (2).
- ➡ The pump is now ready to start a new cycle.

Secondary Fuel filter

- ⇒ Located between the fuel transfer pump and the fuel injection pump manifold.
 - Functions under pressure.
 - Filters very small particles from the fuel that could cause damage to the fuel injection pump assembly and fuel injectors.

Constant bleed orifice

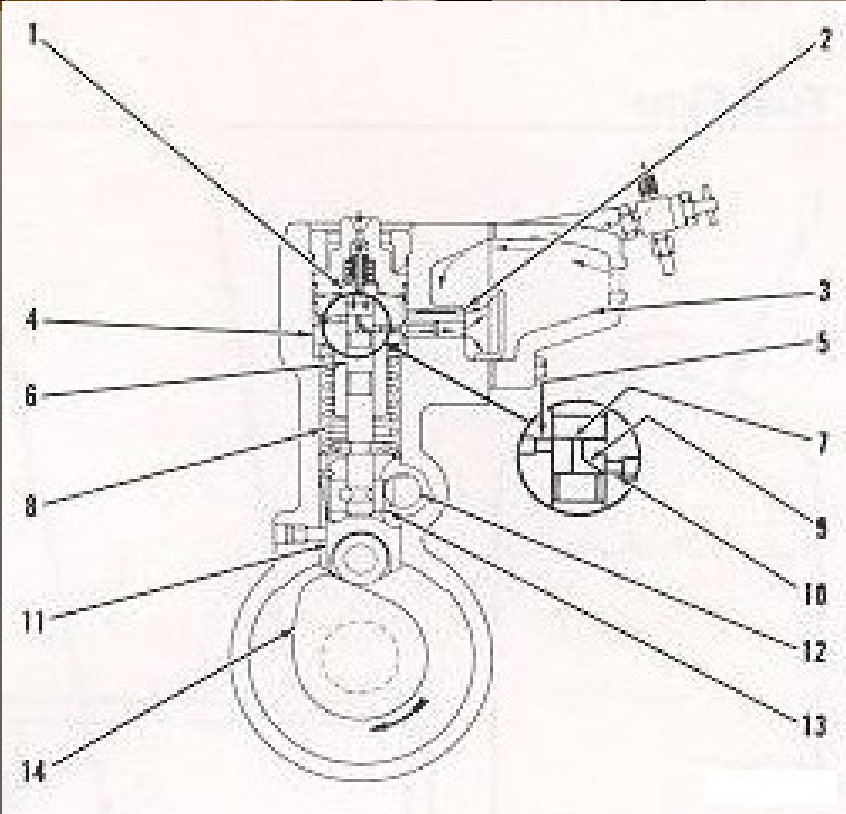
- ⇒ Lets a constant flow of fuel go through the injection pump manifold to the fuel return line and back to the tank.
- ⇒ This helps to keep the fuel cool and free of air.

Fuel Injection Pump Manifold

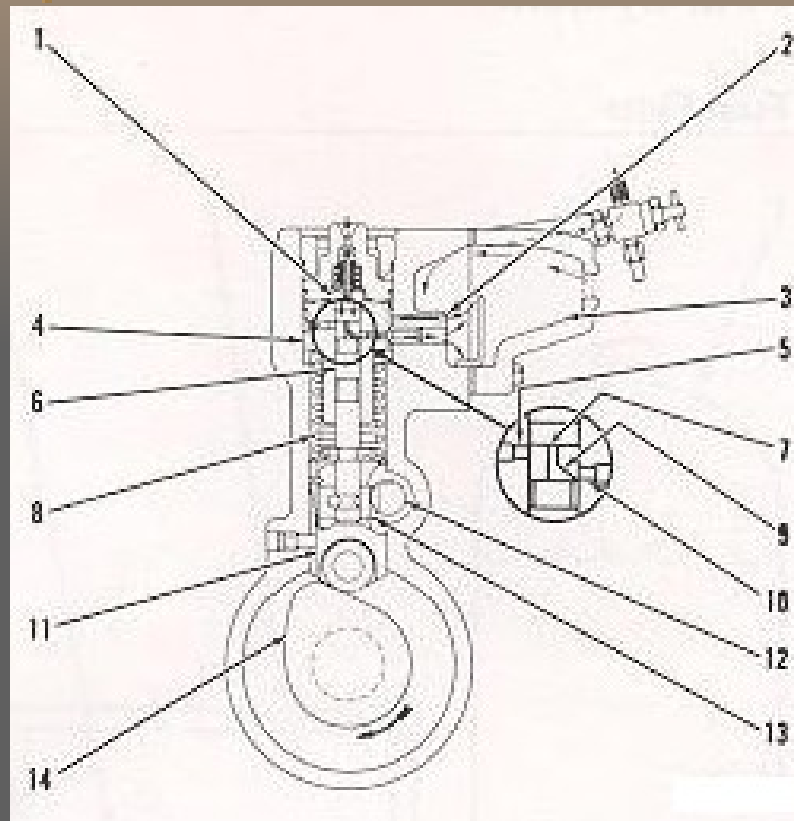
- ⇒ Receives fuel from the secondary fuel filter.
- ⇒ Fuel manifold supplies fuel to the individual fuel injection pumps in the pump housing.

Scroll Fuel injection Pump

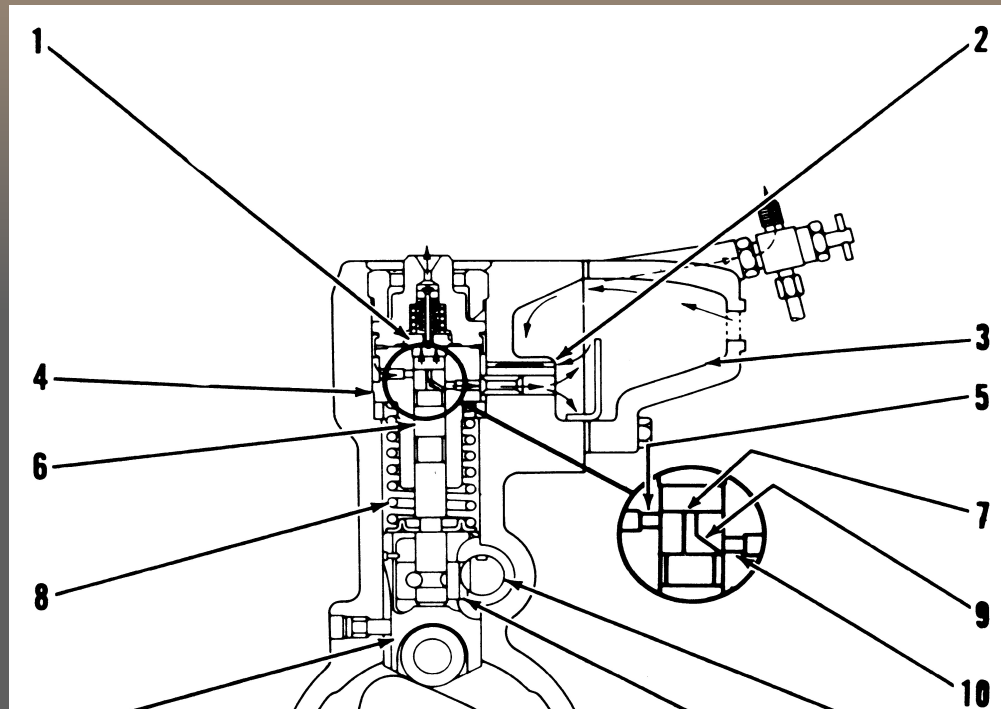
- ⇒ It increases the pressure of the fuel and sends an exact amount to the fuel injector nozzles.
- ⇒ There is one injection pump for each cylinder of the engine.



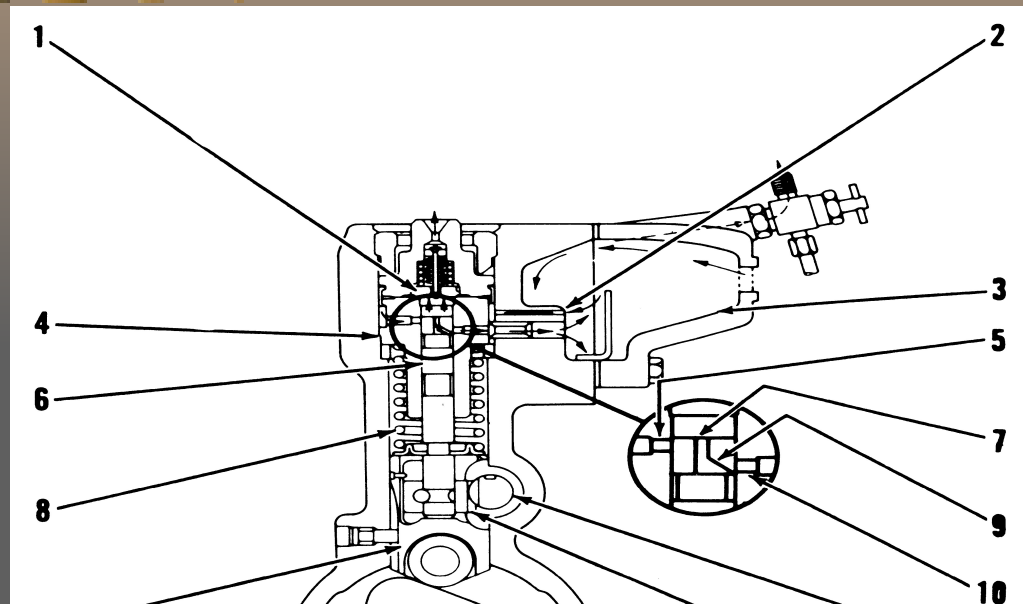
- ➔ The fuel injection pump is moved by cam (14) of the fuel pump camshaft.
- ➔ When the camshaft turns, the cam raises lifter (11) and pump plunger (6) to the top of the stroke.
- ➔ The pump always makes a full stroke. As the camshaft turns farther, spring (8) returns the pump plunger and lifter to the bottom of the stroke.



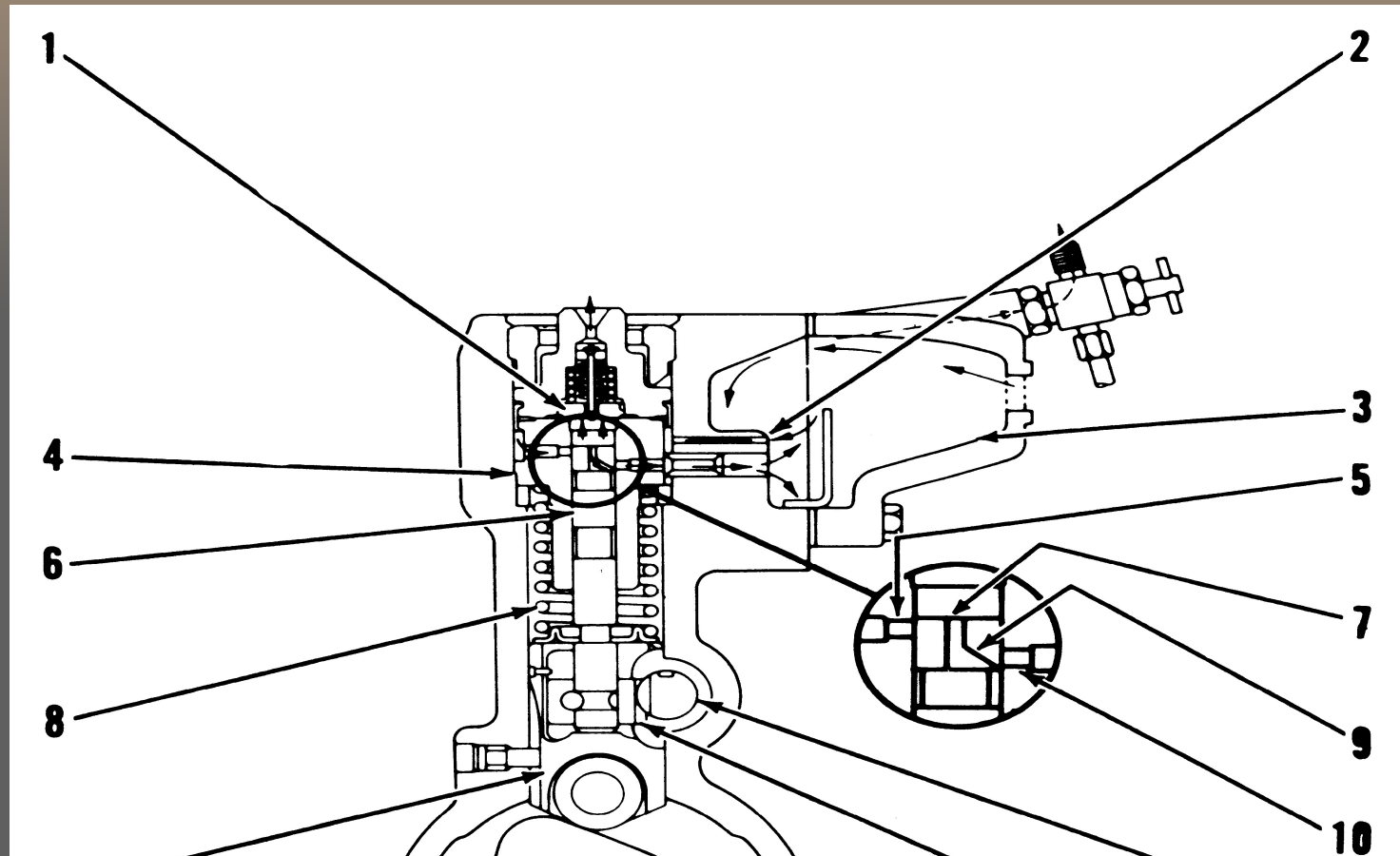
- ➔ When the pump plunger is at the bottom of the stroke, fuel at transfer pump pressure goes into inlet passage (2), around pump barrel (4) and to the bypass closed port (5).
- ➔ Fuel fills the area above the pump plunger.



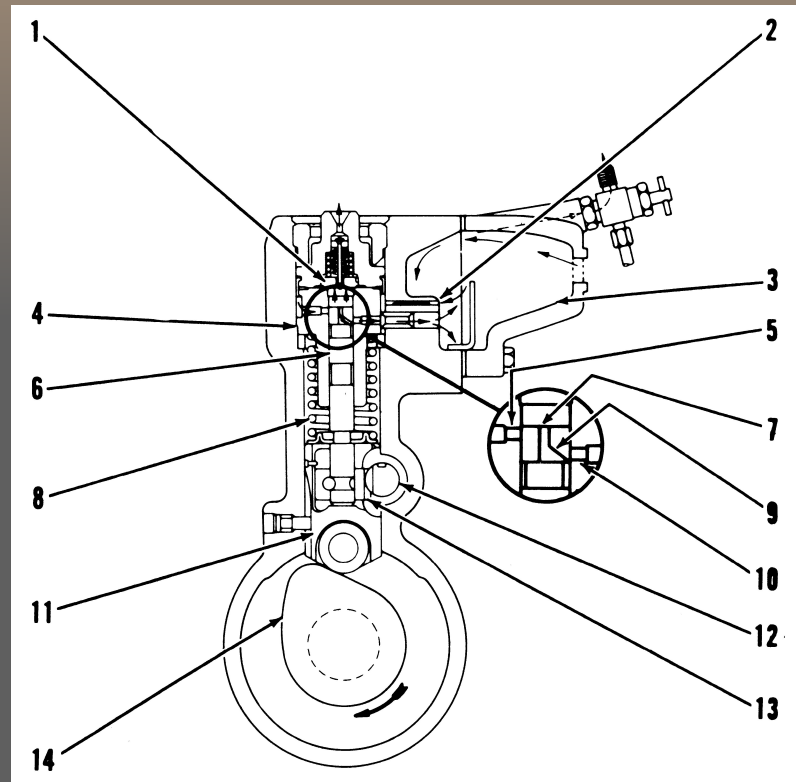
- After the pump plunger begins the up stroke, fuel will be pushed out the bypass-closed port until the top of the pump plunger closes the port. As the pump plunger travels further up, the pressure of the fuel increases.
- At approximately 100 PSI, check valve (1) opens and lets fuel flow into the injection line to the fuel injection nozzle.



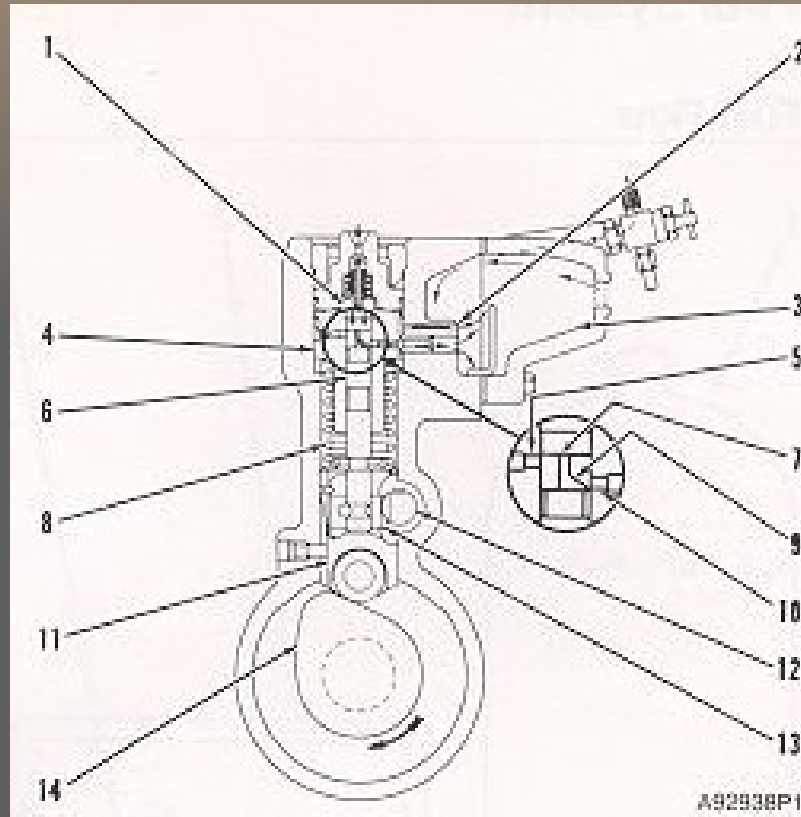
- ➔ When the pump plunger travels farther up, scroll (9) uncovers spill port (10). The fuel above the pump plunger goes through slot (7), along the edge of scroll (9) and out spill port (10) back to the fuel manifold. This is the end of the injection stroke.
- ➔ The pump plunger can have more travel up, but no more fuel will be sent to the injection nozzle. All of this motion is vertical motion (up and down) created by the injection pump camshaft to inject fuel.



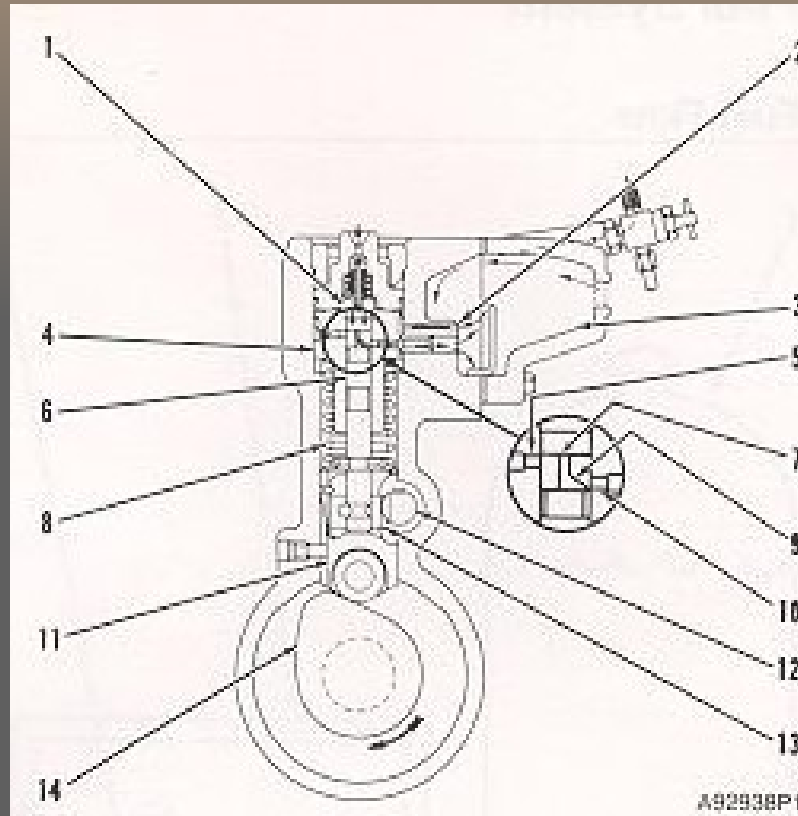
- ➡ When the pump plunger travels down and uncovers bypass closed port (5), fuel begins to fill the area above the pump plunger again, and the pump is ready to begin another stroke.



- ➔ The amount of fuel the injection pump sends to the injection nozzles is changed by the rotation of the pump plunger.
- ➔ Gear (13) is attached to the pump plunger and is in mesh with the fuel rack (12).
- ➔ The governor moves the fuel rack according to the needs of the engine.



- When the governor moves the fuel rack, and the fuel rack turns the pump plunger, scroll (9) changes the distance the pump plunger pushes the fuel between bypass closed port (5) and spill port (10) opening.
- The longer the distance from the top of the pump plunger to the point where the scroll (9) uncovers spill port (10) the more fuel will be injected.

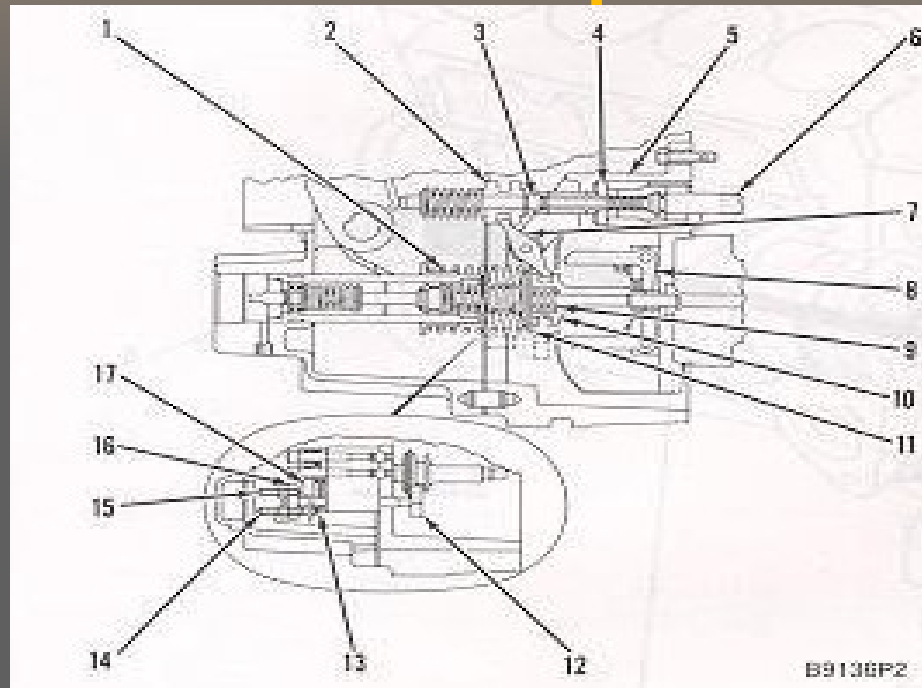


- ➔ To stop the engine, the pump plunger is rotated so that slot (7) on the pump plunger is in line with spill port (10).
- ➔ The fuel will now go out the spill port and not to the injection nozzle.
- ➔ The rotary motion of the fuel rack caused by the governor meters the amount of fuel to be injected.

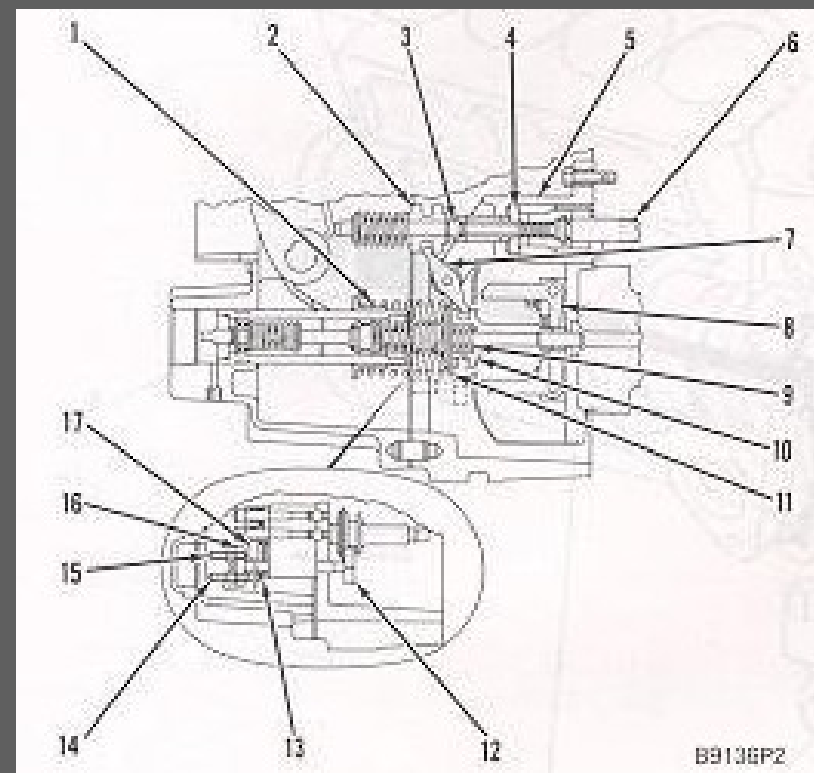
Governor

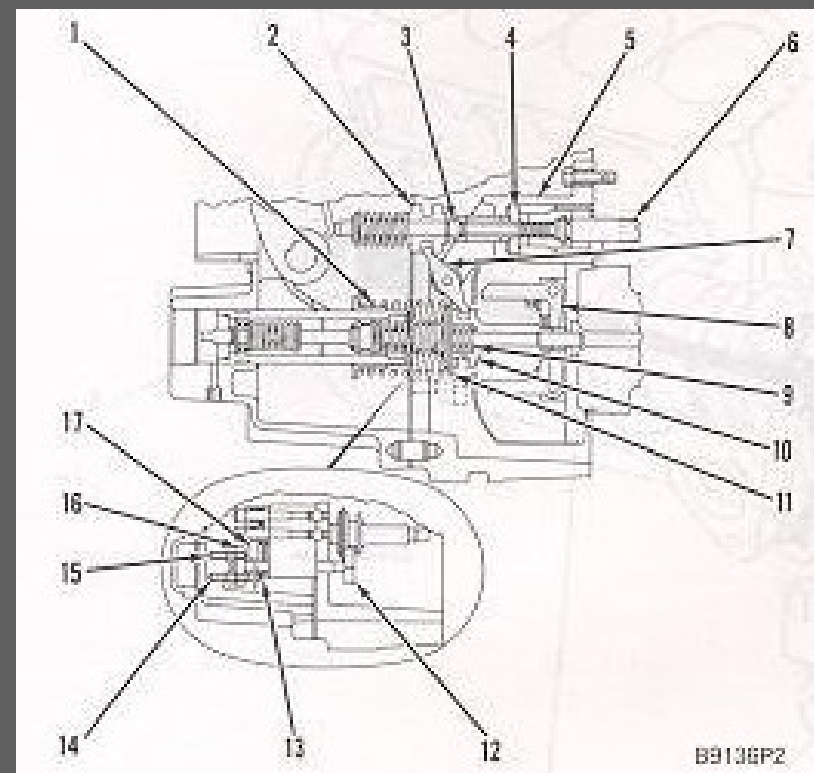
- ⇒ Controls the amount of fuel needed by the engine to maintain a desired RPM.

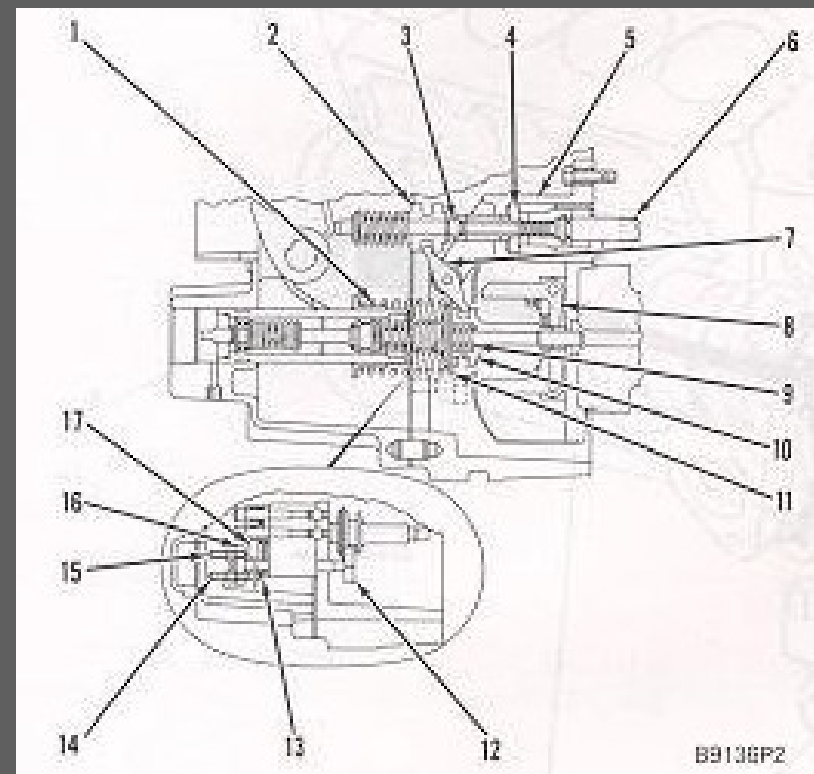
Governor Operation

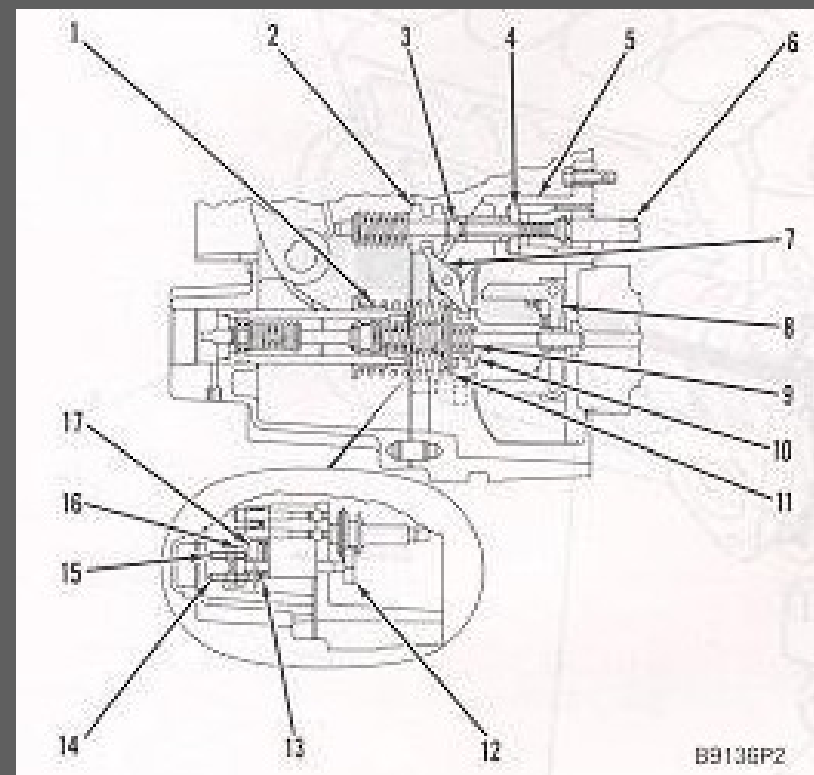


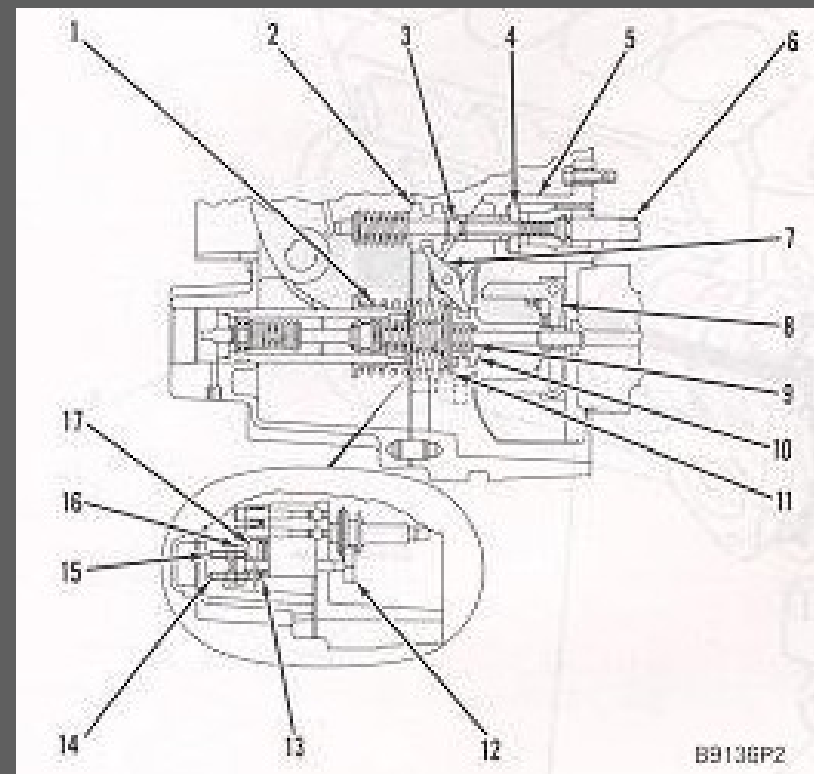
- ➔ The governor flyweights (8) are driven directly by the fuel pump camshaft. Riser (10) is moved by the flyweights (8) and governor spring (1). Lever (7) connects the riser with sleeve (2), which is fastened to valve (3). Valve (3) is part of governor servo (5) and moves piston (4) and fuel rack (6). The fuel rack moves toward the front of the fuel pump housing when moved in the fuel off direction.

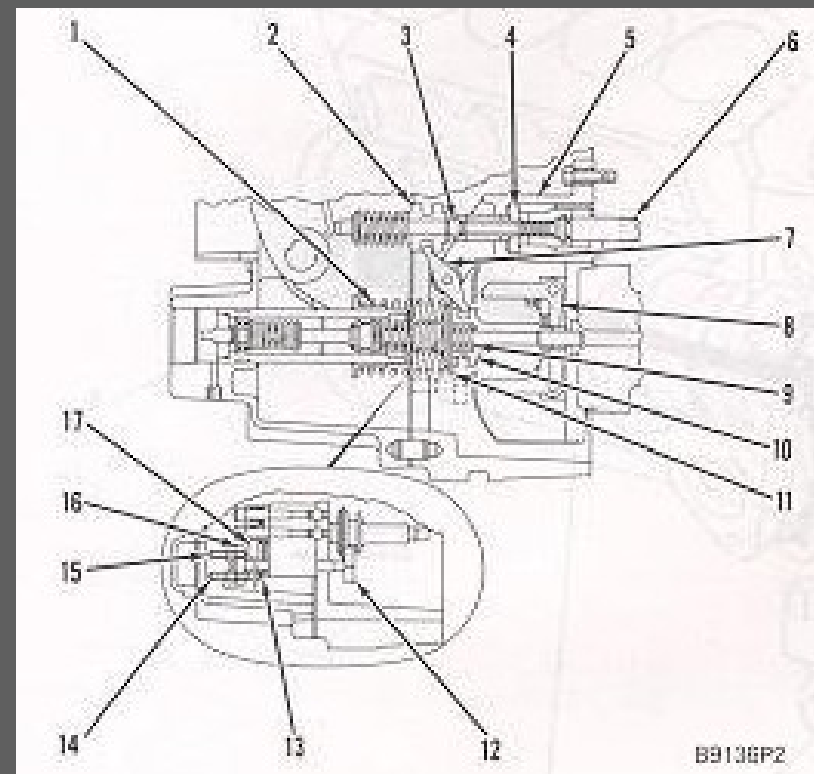


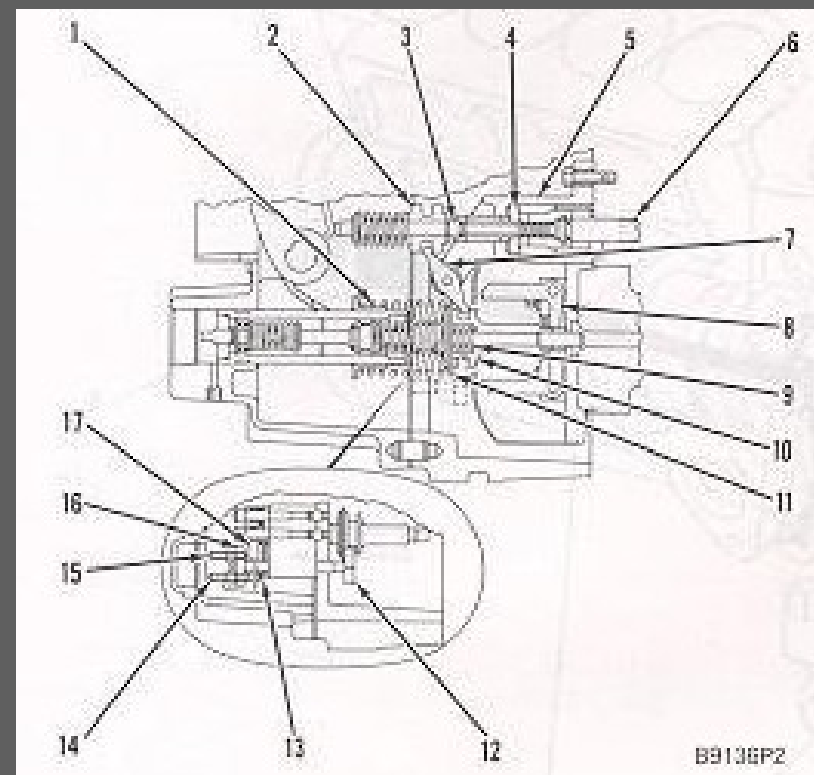


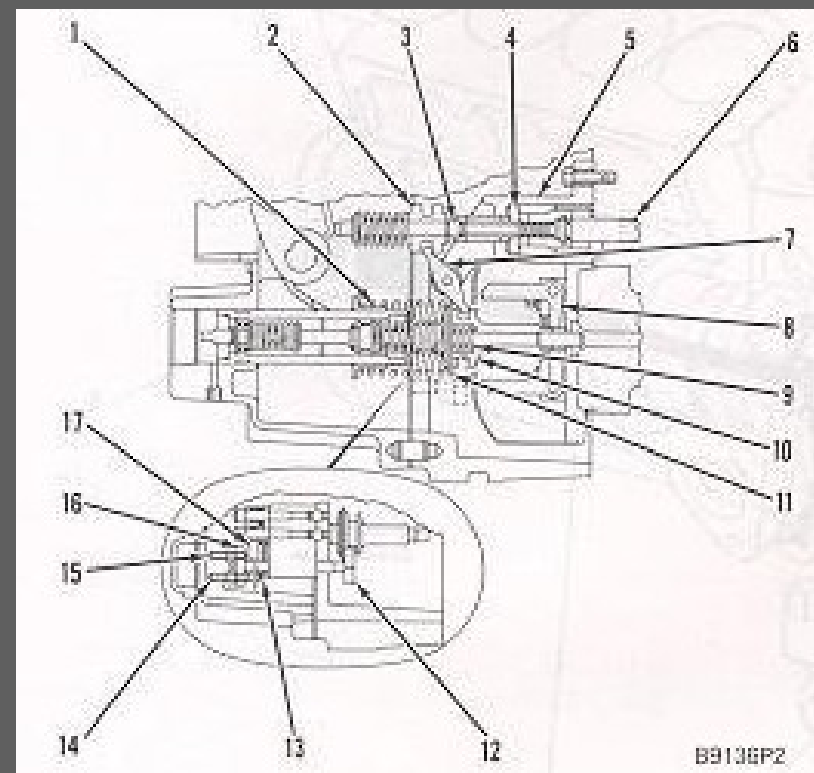


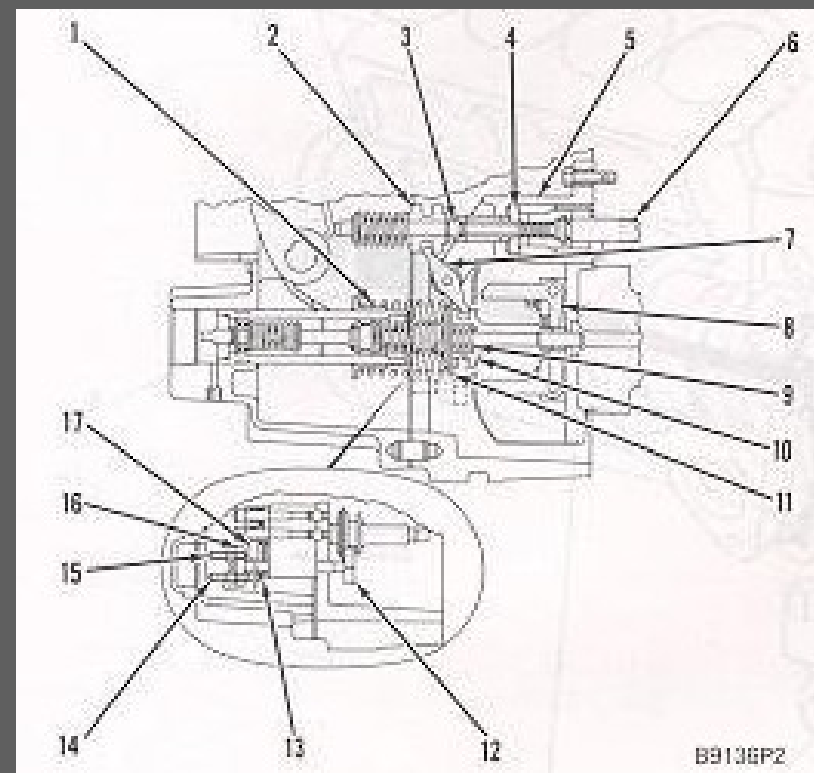


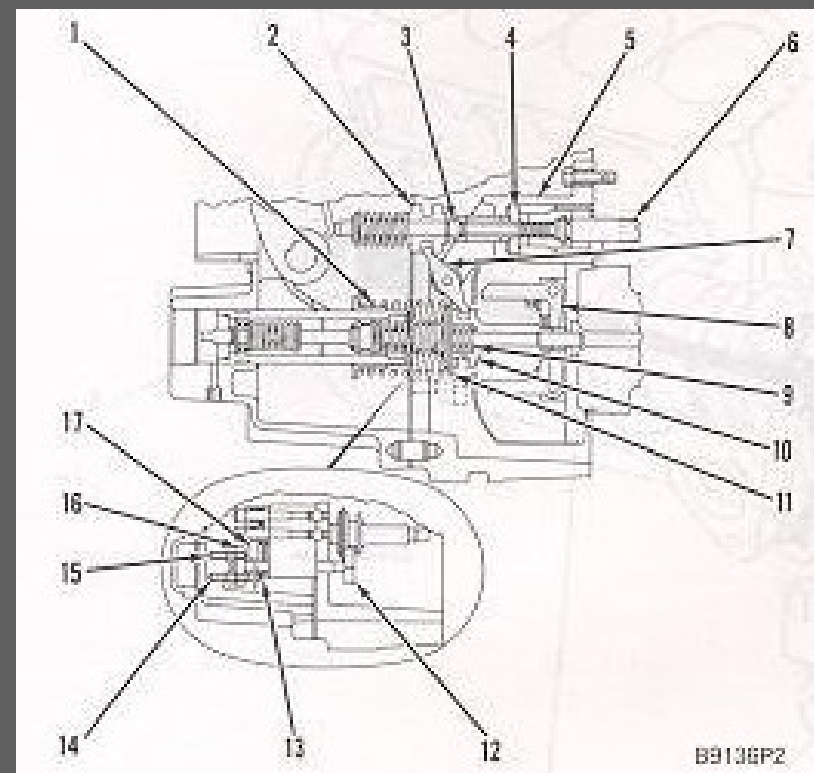


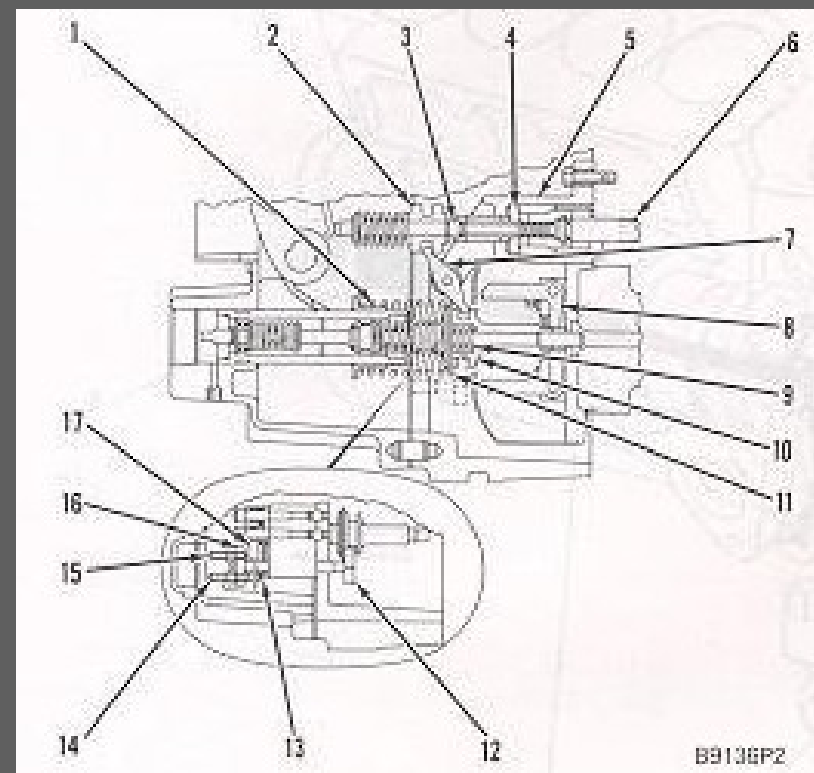




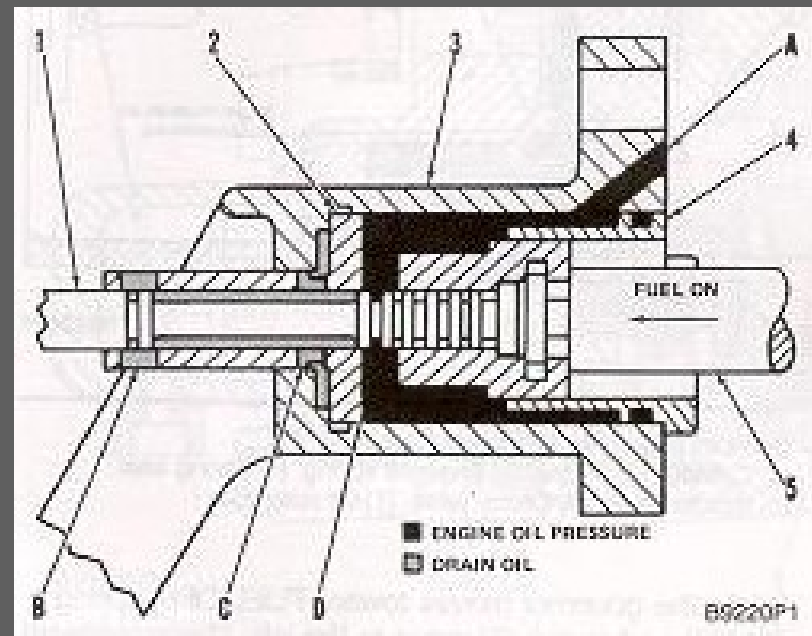




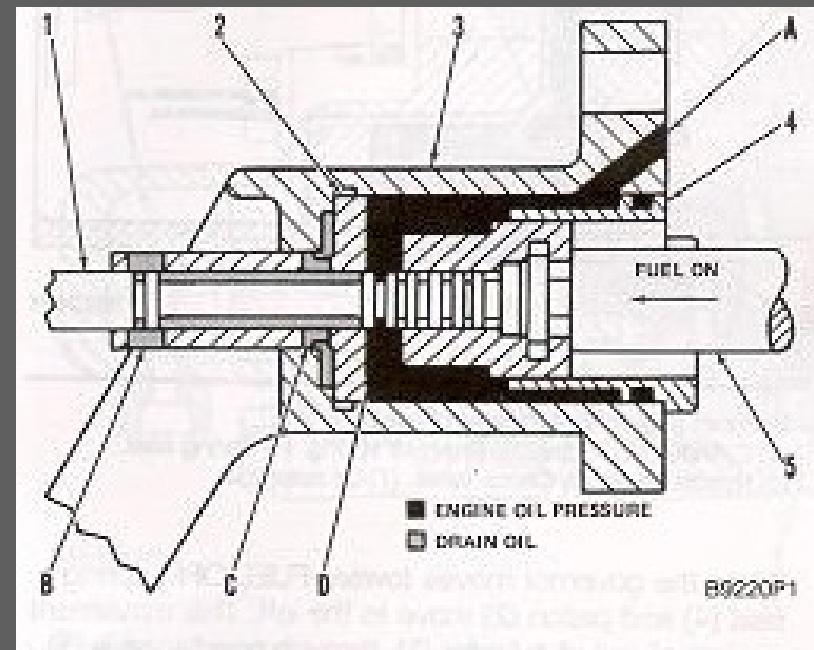




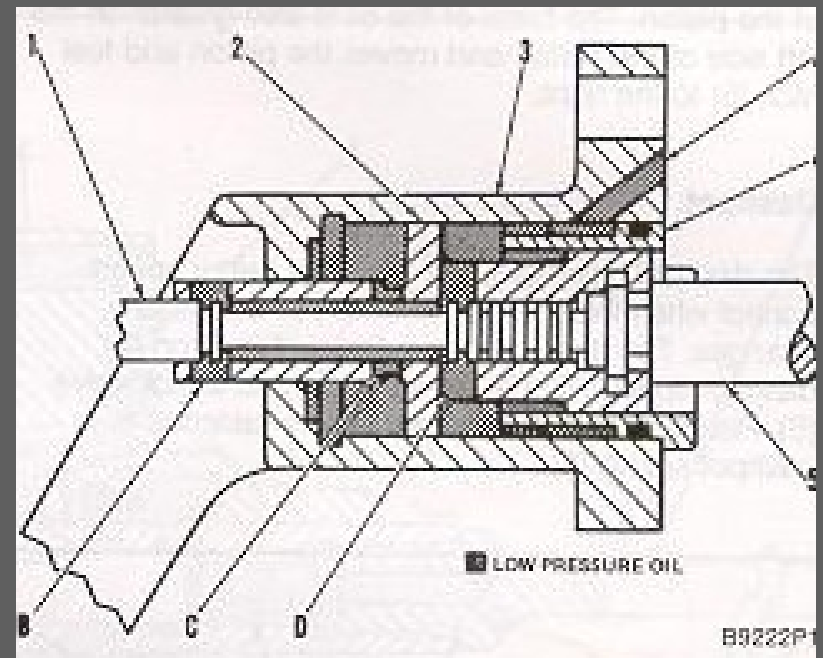
Governor servo



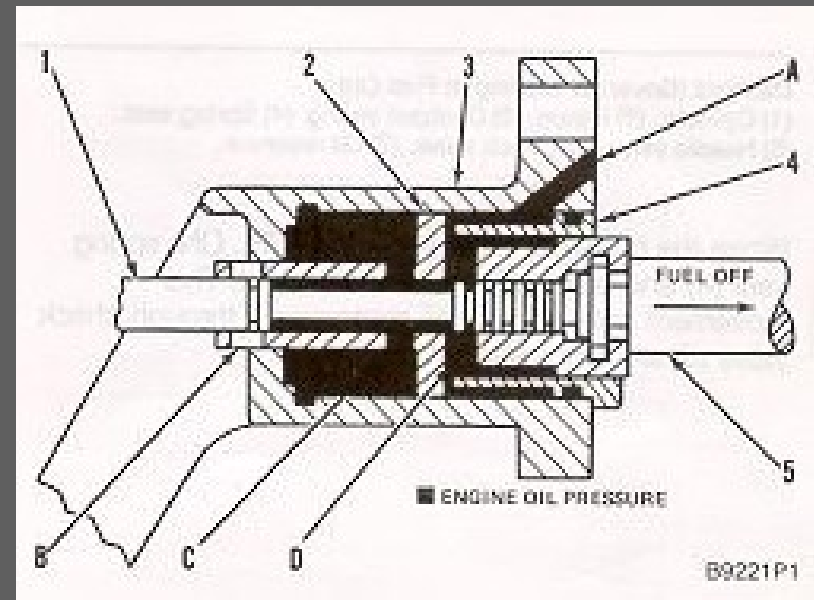
Fuel on position



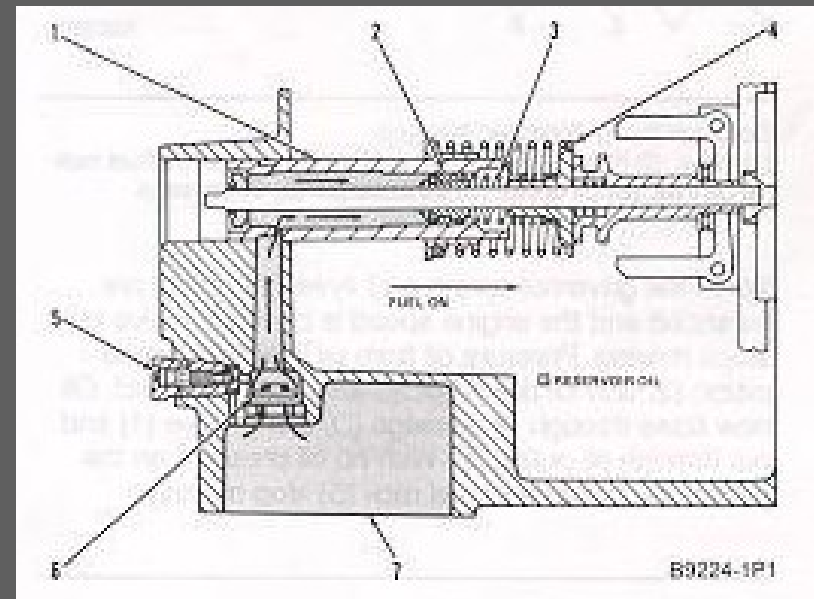
Balanced position



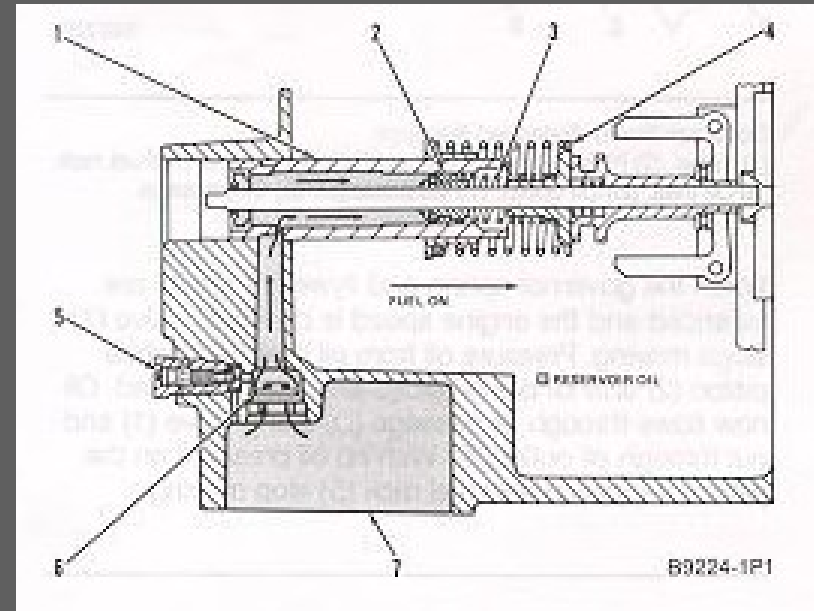
Fuel off position



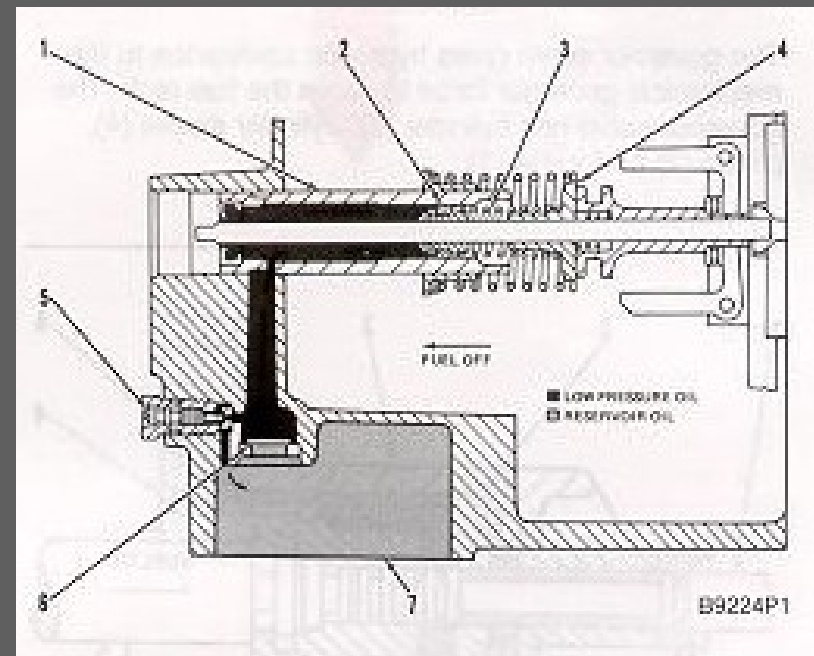
dashpot



Dashpot fuel on position



Dashpot fuel off position

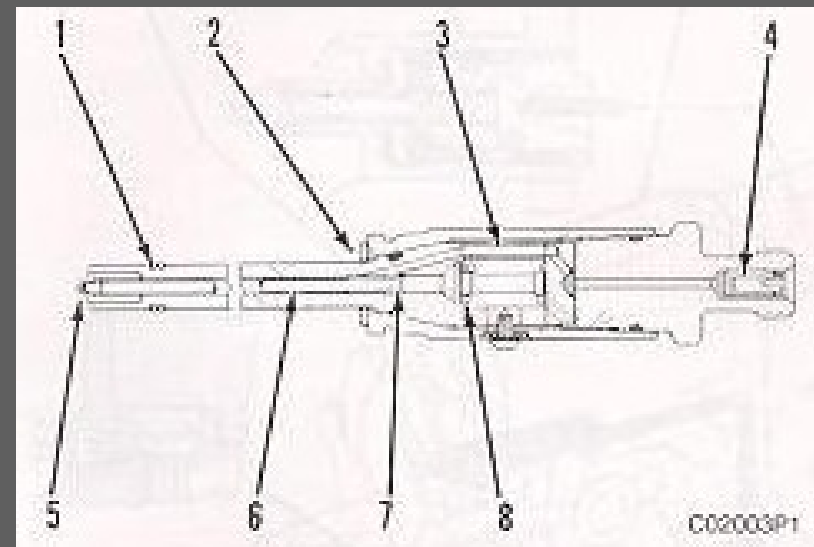




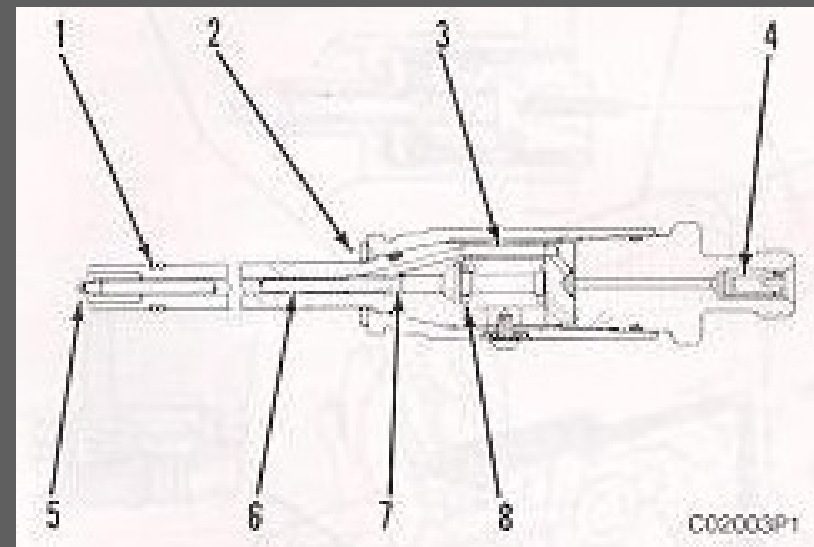
dashpot

Fuel ratio control

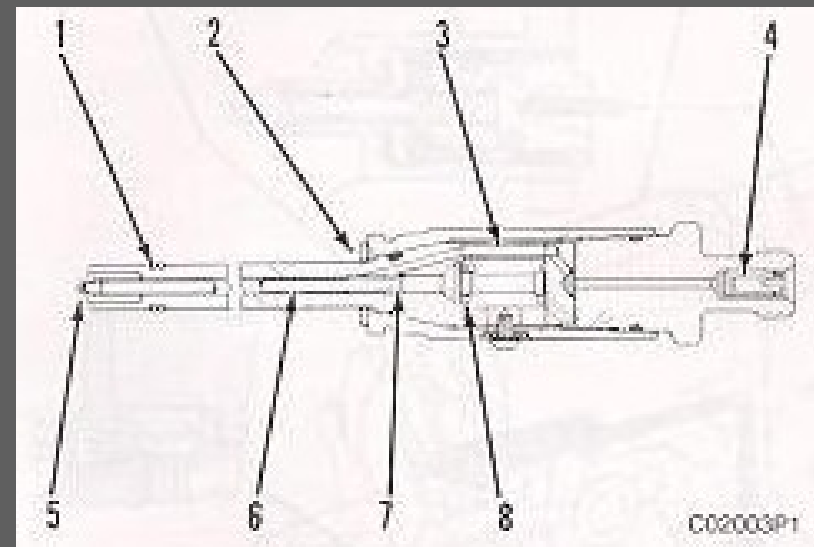
Fuel injector nozzle



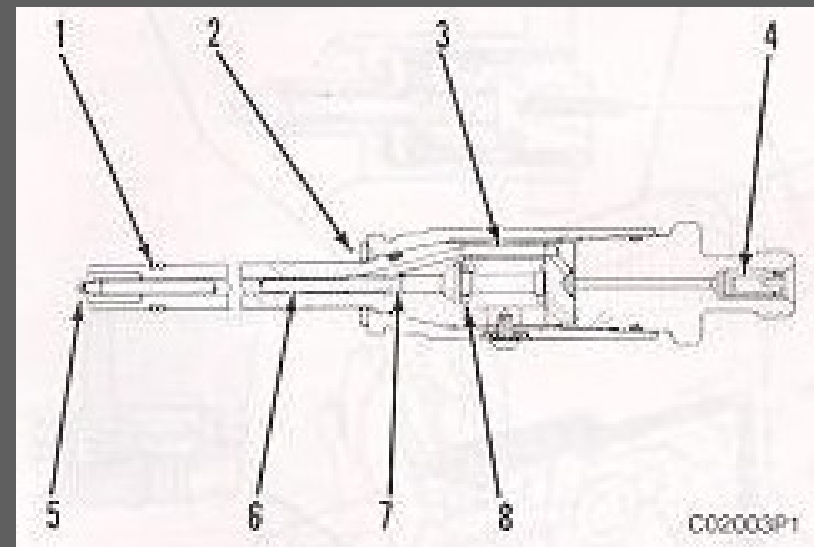
Injector nozzle



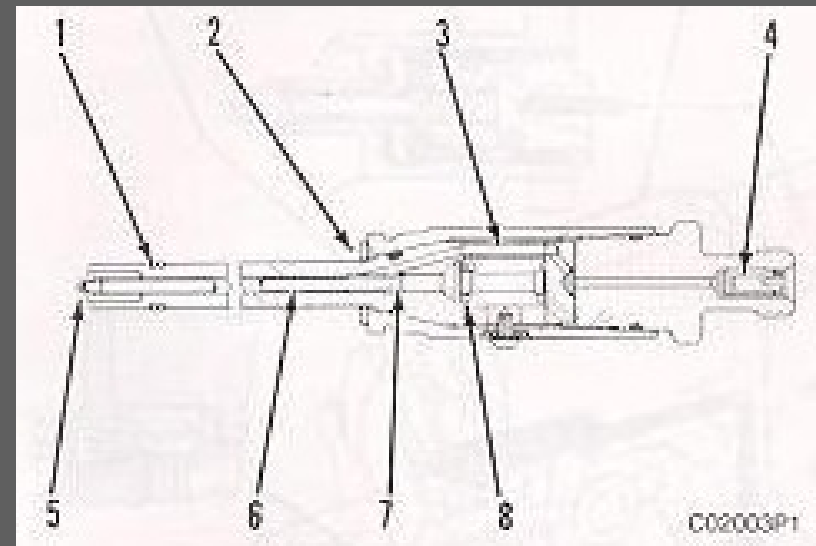
Injector nozzle



Injector nozzle



Fuel injector nozzle adjustment



A landscape image showing a cloudy sky in shades of grey and blue, a horizon line with a thin strip of land in brown and green, and a dark, gradient foreground.

Any Questions?



Take a 10 minute break

Unit Type Injector

